

Self-Report Physical Activity Levels and Sedentary Behaviors of Extremely Low Birth Weight,  
Late Preterm, and Full-Term Control Adolescents

By

Kelli M Teson

Submitted to the graduate degree program in the Department of Health, Sport, and Exercise  
Sciences and the Graduate Faculty of the University of Kansas in partial fulfillment of the  
requirements for the degree of Doctor of Philosophy

---

Chairperson Dr. Leon Greene

---

Dr. Howard Kilbride

---

Dr. Philip Gallagher

---

Dr. Vicki Peyton

---

Dr. Phillip Vardiman

Date Defended: October 6<sup>th</sup>, 2014

Page intentionally left blank

The dissertation committee for Kelli Michelle Teson  
certifies that this is the approved version of the following dissertation:

Self-Report Physical Activity Levels and Sedentary Behaviors of Extremely Low Birth Weight,  
Late Preterm, and Full-Term Control Adolescents

---

Chairperson Dr. Leon Greene

Date Approved: October 6<sup>th</sup>, 2014

Page intentionally left blank

## Abstract

This study evaluated physical activity (PA) levels and sedentary behaviors of extremely low birth weight (ELBW) and late preterm adolescents. The purpose of this study was to determine if the self-reported PA levels, preferences of PA, and sedentary behaviors of unimpaired ELBW (birth weight < 800g) and late preterm (birth weight 1500-2500g and < 37 weeks gestational age) adolescents differed significantly ( $p < 0.05$ ) from full-term control adolescents (birth weight > 2500g and > 37 weeks gestational age). Additionally, PA levels were compared to maximal oxygen consumption measurements. Sedentary behavior characteristics and screen time usage (television, computer, and video games) were also compared. The participants were 61 ( $n=17$  ELBW,  $n=21$  late preterm,  $n=23$  full-term) adolescents, ages 12-20, born in the Kansas City area between January, 1993 to December, 1995.

A modified version of the Modifiable Activity Questionnaire (MAQ) was used to determine past year MET hours per week of PA and preferences of PA. The MAQ results indicated no statistically significant difference ( $p > 0.05$ ) in PA between the three groups and PA intensity preferences were similar among the three groups ( $p > 0.05$ ). Maximal oxygen consumption was obtained utilizing a ramp treadmill protocol to exhaustion. A statistically significant positive correlation ( $r = 0.450$ ,  $p = 0.000$ ) was obtained between the reported PA and maximal oxygen consumption. Sedentary behavior and screen time were assessed utilizing a Sedentary Behavior Questionnaire. No statically significant differences were found when comparing time spent in sedentary behaviors or screen time utilization ( $p > 0.05$ ).

Findings resulted in the conclusions that these unimpaired ELBW and late preterm adolescents did not appear to be notably impacted by their prematurity in a way that manifested

in significantly decreased participation in physical activities; with the MAQ allowing for appropriate estimation of regular physical activity in these premature adolescents. Additionally, all three groups of adolescents were found to be making the healthiest choice of physical activity by frequently selecting physical activity at a moderate intensity level. Finally, unimpaired ELBW and late preterm adolescents do not favor sedentary activities more than full-term control adolescents; however, they should be educated on healthy lifestyle habits and strategies to help reduce time spent in sedentary pursuits.

## Acknowledgments

I am beyond thankful for the army of people that have encouraged me to embark on this doctoral degree journey three years ago. First I want to express my gratefulness to my husband Brian, who has taken on more than his share of work while at home with a brand new baby and toddler. I appreciate all the bedtimes, dinners, and nights alone with the kids so I could attend class or sneak away to the basement to do some typing. Thanks for listening to all of my academic worries, and being that shoulder to cry on when I didn't think I could go on. You have always been so supportive of my career goals and my passion for learning, and I know this would not have been possible without your faithful love and support.

To my advisor, Dr. Leon Greene, was just brave enough to take on a full-time working, mother of two young children, who wanted to tackle one of her dreams. Thank you for your guidance and direction, with the ability to see through my crazy schedule to know that I would give you everything I had to complete this process. You trusted me and gave me valuable advice and a listening ear when I needed it.

I owe a special thanks to my mentor, fellow co-worker, and friend, Dr. Richard Sabath. Without your dedication and gentle suggestions, I may have never seen the potential that you always saw in me. Your love for the field of pediatric exercise physiology has helped me to see what truly amazing things can happen when you are passionate about your career. Thanks for picking up the slack at work when I needed to be gone for class or exams and sticking with me to the end, through thick and thin. I will definitely miss our talks about life, sports, and ducks, and I wish you the best of luck in your much deserved retirement!

I would also like to thank my other committee members. Dr. Peyton, who provided excellent guidance on statistical tests that previously made no sense to me; Dr. Gallagher, who has put up with my Type AAA personality for many years and can still laugh about it; Dr. Vardiman, who agreed to step in at the last minute and help me finish out this crazy process as painlessly as possible; Dr. Satinsky, who had to leave before her hard work came to fruition, but still provided me with a welcoming atmosphere as a student in her numerous classes ; and a special thanks to Dr. Kilbride, who not only agreed to serve on my committee, provide great feedback, and make the commute to Lawrence in the midst of a really busy schedule, but also to allow me to utilize his research study to focus on exercise-related variables. You were nothing but supportive throughout this process and look forward to working with you in the future.

Finally, to the many others. To my amazing mother and sister, and my fabulous in-laws and other family members, for never questioning my decision to pursue a PhD and providing prayer and encouragement when I needed it (and always lending a helping hand to Brian and I when we needed it). To my fellow PhD students, Katy Rollins, Dr. Timson, Dr. Moodie, Melissa Linden, Dr. Touchberry, Dr. Kudrna, and also Linda, Carole and others at KU. Thank you for being wonderful friends and sources of support (and letting me laugh and/or cry, when I wasn't sure if things could get any worse). To my friends and colleagues at work, especially Cheyenne and the nurses, and Dr. White, thank you for your endless encouragement.

I would also like to mention my two children, Colin and Maggie. You have been very patient with me throughout this process (while asking me every night if I *still* have homework to do – and every night hearing me grumble “yes”); and for instilling in me the bravery that helped me to make the best decision possible for our family. We did this for you, kiddos.



## Table of Contents

Chapter I.....	1
Introduction.....	1
Statement of Purpose .....	2
Research Questions .....	2
Significance.....	3
Scope of the Study .....	5
Assumptions.....	6
Limitations .....	6
Definitions.....	8
Chapter II .....	10
Review of the Literature .....	10
Introduction.....	10
Survival rates .....	10
Prevalence of children born ELBW and late preterm.....	11
Health outcomes in children born ELBW and late preterm.....	12
Neurodevelopmental disabilities.....	14
Social/behavioral/psychological disorders.....	14
Cardiovascular disorders.....	15
Physical activity levels of children born ELBW and late preterm.....	16
Physical activity intensity .....	17
Exercise capacity .....	18
Physical activity limitations of children born ELBW and late preterm.....	19
Personality traits.....	20
Biological factors .....	21
Health outcomes of physical activity .....	22
Sedentary behaviors of children born ELBW and late preterm.....	23
Health outcomes of sedentary behavior .....	25
Screen Time .....	25
Primary theoretical frameworks.....	27
Parental Overprotection .....	27

Problems and issues arisen in the study area .....	30
Summary of literature review .....	32
Chapter III.....	34
Methods.....	34
Purpose.....	34
Research Design.....	34
Review of Literature .....	35
Subject/Site Selection Procedures.....	35
Data Collection Procedures.....	36
Testing Instruments.....	38
Modifiable Activity Questionnaire for Adolescents .....	38
Treadmill Exercise Testing .....	41
Sedentary Behavior Questionnaire .....	43
Data Analysis and Hypothesis Testing .....	46
Research Question One .....	47
Sub-question a.....	47
Research Question Two .....	47
Research Question Three .....	47
Sub-question a.....	48
Data Reporting .....	48
Chapter IV .....	49
Results.....	49
Purpose.....	49
Sample Demographics .....	49
Research Question One .....	54
Sub-question a) .....	55
Research Question Two .....	56
Research Question Three .....	57
Sub-question a) .....	58
Chapter V .....	59
Discussion .....	59

Purpose.....	59
Research Question One .....	59
Sub-question a) .....	62
Research Question Two .....	63
Research Question Three .....	65
Sub-question a) .....	68
Chapter VI.....	71
Summary, Conclusions, and Recommendations.....	71
Summary .....	71
Conclusions.....	73
Recommendations.....	74
References.....	76
Appendix A.....	93
Appendix B .....	94
Appendix C .....	95
Appendix D.....	96

### **List of Tables**

Table 1: <i>CMH Max treadmill protocol (one minute stages)</i> .....	43
Table 2: <i>Demographics (N=61)</i> .....	51
Table 3: <i>Subject characteristics (N=61)</i> .....	52
Table 4: <i>Physical activity characteristics and maximal oxygen consumption</i> .....	53
Table 5: <i>Weekend total sedentary behavior time and screen time</i> .....	53
Table 6: <i>Average number of physical activities reported with light, moderate, and hard intensities (N=61)</i> .....	56

# **List of Figures**

Figure 1: <i>Self-reported MET hours per week by group</i> .....	54
Figure 2: <i>Maximal oxygen consumption and self-reported past year MET hours of physical activity</i> .....	55
Figure 3: <i>Self-reported weekend sedentary behaviors by group</i> .....	57
Figure 4: <i>Self-reported screen time usage by groups</i> .....	58

## **Chapter I**

### **Introduction**

Neonatal medicine has seen advances allowing for increased survival of those born with lower birth weights. There are uncertainties about these infants developing and leading normal, productive lives (Hack, Klein, & Taylor, 1995). Extremely low birth weight (ELBW) children have a broad spectrum of growth, health, and developmental outcomes, with the developmental sequelae for most ELBW infants including mild problems in cognition, attention, and neuromotor functioning, with some long-term follow up studies indicating adverse consequences of being born ELBW still apparent in adolescence (Saigal & Doyle, 2008; Salt & Redshaw, 2006). There is a well-established foundation of literature on the health outcomes following premature birth and ELBW, but the field is only beginning to expand on other aspects, such as physical activity levels and sedentary behaviors of this population.

Dahan-Oliel (2012) reported that preterm birth and leisure participation in adolescents born prematurely detailed fewer social activities, hobbies outside school, and sports and physical activity than term controls. Similarly, young adults born with very low birth weight (VLBW) to ELBW reported less leisure-time conditioning, physical activity, and shorter exposures to leisure-time physical activity (Hovi et al., 2007; Kajantie et al., 2010). Some studies underscore the importance of participating in physical activity and other types of social, skill-based and recreation activities so as to pursue healthy and active lifestyles in adolescence and into adulthood (Dahan-Oliel, Mazer, & Majnemer, 2012). While common features have been identified in examining physical activity, sedentary behaviors of ELBW and late preterm adolescents remain largely unstudied. Furthermore, only a few studies conclude that ELBW adolescents and young adults lead a more sedentary lifestyle than their peers due to reporting less

active physical lifestyles and limited participation in sports and strenuous activities (Rogers, Fay, Whitfield, Tomlinson, & Grunau, 2005; Saigal et al., 2007). Conclusions regarding sedentary behaviors and lifestyles of ELBW adolescents and young adults may be inaccurately described, as sedentary behaviors have not been directly assessed in current literature. Therefore, this study will utilize questionnaires designed for estimating both physical activity levels and specific sedentary behaviors, which eliminates the potential for inaccurate descriptions of sedentary behaviors in this unique population.

### **Statement of Purpose**

The purpose of this study was to determine whether or not the self-reported physical activity levels and preferences of physical activities of unimpaired ELBW and late preterm adolescents differed significantly from full-term control adolescents. Additionally, physical activity characteristics were further examined by comparing the self-reported physical activity levels with measured peak oxygen consumption. Self-reported leisure-time sedentary behavior characteristics and screen time usage (television, computer, and video games) were also examined.

### **Research Questions**

The research questions for this study were:

1. Are there significant differences in the current self-reported physical activity levels of adolescent ELBW, late preterm, and full-term controls?

Sub-question a). Is there a relationship between these self-reported physical activity levels and measured treadmill maximal oxygen consumption?

2. Are there significant differences in the intensity levels of the preferred physical activities between the three groups?
3. Are there significant differences in the current self-reported sedentary behaviors of adolescent ELBW, late preterm, and full-term controls?

Sub-question a). Is there a significant difference in self-reported screen time usage between the three groups?

### **Significance**

Children who are born very preterm and/or ELBW are at an increased risk for a range of adverse neonatal outcomes. These outcomes may differ in short-term and long-term consequences, as well as degree of severity. As children are now thriving in adolescence and adulthood, research has begun to focus attention on other health outcomes of extreme prematurity, including physical activity levels and sedentary lifestyles.

Observational studies provide compelling evidence that regular physical activity and high fitness levels are associated with a reduced risk of premature death from any cause and from cardiovascular disease in particular among asymptomatic men and women (Blair et al., 1995; Oguma & Shinoda-Tagawa, 2004). Furthermore, a dose-response relationship appears to exist, such that people who have the highest levels of physical activity and fitness are at lowest risk of premature death (Warburton, Nicol, & Bredin, 2006). Lower birth weights have been associated with reduced physical performance, including muscle strength (Yliharsila et al., 2007), muscle endurance (Ridgway et al., 2008) and aerobic fitness in both childhood and adulthood (Ridgway et al., 2008) and it has been suggested that this lower physical capacity may lead to reduced levels of physical activity (Andersen et al., 2009).

Excessive sedentary time is not the same as lack of exercise and, as such, has its own unique metabolic consequences (Hamilton, Hamilton, & Zderic, 2007). As such, it is important to not only assess the physical activity levels, but also the sedentary behaviors to establish anticipated health outcomes of a specific population. ELBW survivors often suffer from impairments that could limit involvement in physical activity and lead to preference of sedentary behaviors. Poor early coordination combined with low self-confidence may contribute to lack of establishment of health levels of physical activity in childhood as well as lack of common knowledge of and skills for group sports and activities (for example, how to swim, catch a ball, etc). This carries into young adulthood, contributing to poor self-image and lack of association with more socially and physically active peers, and potentially adding to the overall tendency of ELBW adolescents to be more sedentary compared with their peers (Rogers et al., 2005). It is important for children and adolescents to feel confident in their ability to participate in regular physical activity, as this may aid in decreasing sedentary behaviors and lifestyles and increase physical activity levels.

Interestingly, the available evidence indicates that sedentary behaviors are not the mirror image of physical activity and that the two behaviors are relatively uncorrelated, further suggesting that being sedentary should not be inferred from low levels of moderate to vigorous physical activity (Owen, Leslie, Salmon, & Fotheringham, 2000; Pate, O'Neill, & Lobelo, 2008). While excessive sedentary time is a health risk, the correlates of adolescent sedentary behaviors are not clear (Norman, Schmid, Sallis, Calfas, & Patrick, 2005).

The potential contributions of this study are numerous. The expansion of the assessment of health outcomes of ELBW and late preterm adolescents to include physical activity patterns and sedentary behaviors will reveal important information for clinicians and family members.



ELBW and late preterm children have been noted to be at risk for early-onset adult metabolic and cardiovascular diseases such as diabetes, hypertension, ischemic heart disease, and strokes (Rogers et al., 2005). As such, establishing early, adequate levels of fitness and activity may be particularly important in former ELBW and late preterm infants for improvement in quality of life as adolescents and young adults at risk for adverse outcomes. Investigating both physical activity and sedentary behaviors together could contribute to the field by allowing clinicians to better understand ELBW and late preterm children's health outcome's impact on their levels of physical activity and sedentary behavior. Additionally, there is a need for further research in the management of the late preterm individuals, especially comparing them to full-term individuals, as this is the population they are often grouped into. Exploring the differences in lifestyles between ELBW, late preterm, and full-term adolescents is essential to determine if being born moderately preterm has long term implications in the adolescent population. All of the contributions taken together could aid in establishment of the need for future intervention, adoption of healthy behaviors and overcoming barriers for this unique and vulnerable population.

### **Scope of the Study**

There were three delimitating factors to this study. They are:

1. Participants were born in one of two large University of Missouri Kansas City teaching hospitals participating in the study in the Kansas City metropolitan area.
2. Participants range in ages, 12- 20 years at the time of testing.
3. Self-report data were acquired through the use of a version of the Modified Activity Questionnaire for Adolescents and the Wake Forest University Sedentary Behavior Questionnaire.

### **Assumptions**

The assumptions for this study were:

1. Participants responded honestly and accurately to the items on the questionnaires.
2. Participants comprehended questionnaire items as intended by the questionnaire developers, thus allowing reliable answers.
3. Participants surveyed were a representative sample of unimpaired ELBW, late preterm, and full-term adolescents in the Midwest region.

### **Limitations**

There were five limitations to the study:

1. Participants may not be representative of a more diverse sample of ELBW, late preterm, and full-term adolescents nationwide, as the sample is small and relatively homogeneous and may be more representative of neurologically intact ELBW and late preterm adolescents.
2. ELBW and late preterm participants were part of a longitudinal follow-up of a previous study, while some of the full-term adolescents were recruited after the previous study in an attempt to equalize sample sizes.
3. Both questionnaires required participants to have appropriate memory and recall skills allowing for reporting accurate physical activity and sedentary behaviors.

4. Samples sizes were small, as unimpaired ELBW and late preterm adolescents are a rare, distinct group. As such, there may not have been enough power to detect differences if they existed in the study.
5. Socioeconomic status has been widely reported as a determinant of physical activity in the adult population. Socioeconomic status was neither collected nor analyzed in this study and may impact the results found regarding self-reported physical activity levels.

## Definitions

For the purpose of this study, the following definitions were used:

**Extremely Low Birth Weight (ELBW):** A category of infants born with a birth weight of less than 800 grams.

**Very Low Birth Weight (VLBW):** A category of infants born with a birth weight of less than 1500 grams.

**Late Preterm:** A category of infants born with a birth weight of 1500-2500 grams and at a gestational age of less than 37 weeks.

**Preterm Deliveries:** A category of infants that are born at a gestation age of less than 37 weeks.

**Regular Physical Activity:** An individual that meets the current minimal exercise recommendations of about 30 minutes per day for about five days per week of at least moderate activity level.

**Physical Fitness:** A set of attributes that people have or achieve that relates to the ability to perform physical activity.

**Exercise Capacity:** The amount of physical exertion someone can sustain in a given activity (Clemm et al., 2012).

**Hard Intensity Physical Activity:** Any physical activity that is difficult enough to cause heavy breathing and fast heart rates (examples include playing basketball, jogging, or fast bicycling) with a metabolic equivalent value of greater than or equal to 6.1 METs.

**Moderate Intensity Physical Activity:** Any physical activity that is difficult enough to noticeably elevate heart rate while still able to carry on a conversation (examples include brisk walking or weight training) with a metabolic equivalent value of 3.1-6.0 METs.

**Light Intensity Physical Activity:** Any physical activity that is not difficult enough to cause heavy breathing or fast heart rates (examples include leisure walking or slow bicycling) with a metabolic equivalent value of 1.6-3.0 METs.

**MET Hours per Week:** A measure of physical activity found by taking the total product of the metabolic equivalent value (the energy cost of the activity) for a specific physical activity multiplied by the hours expended in that activity each time, with all activities summed over a given time period.

**Sedentary Behaviors:** Any waking behavior (not including sleeping), primarily sitting or reclining, that requires very low energy expenditure of between 1.0 and 1.5 metabolic equivalents (Bond et al., 2013)

**Screen Time:** The amount of time spent sitting while utilizing a device such as a television, computer, or gaming console to watch television programs, movies, or play video games.

**Kruskal-Wallis Test:** A nonparametric statistical technique that assesses the differences among three or more independently sampled groups. The Kruskal-Wallis is the nonparametric version of the one way analysis of variance (ANOVA) and is designed to be appropriate when assumptions of normal underlying distributions cannot be made and when sample sizes are of unequal size (Castellan, 1988; Kruskal & Wallis, 1952).

## **Chapter II**

### **Review of the Literature**

#### **Introduction**

Neonatal intensive care, introduced in the 1960s and further refined in the 1970s and 1980s, led to improved survival for infants of very low birth weight (Stahlman, 1984). Because of prevention and prompt interventions, from 2000 to 2009, mortality for infants weighing 501 to 1500 grams decreased from 14.3% to 12.4%. Major morbidity in survivors decreased from 46.4% to 41.4% (Horbar et al., 2012). Late preterm infants (those with a gestational age of less than 37 weeks and a birth weight between 1500-2500 grams) are the fastest growing subgroup of neonates and constitute approximately 75% of all preterm births in 2009. And although mortality rates are much lower (7.5 times) in those infants born late preterm than in very preterm children, these rates are almost ten times higher than in full term children (de Jong, Verhoeven, & van Baar, 2012). The survival rates for preterm births have increased because of technological advances and the collaborative efforts of obstetricians and neonatologists (Saigal & Doyle, 2008). Before the widespread use of assisted ventilation in the 1970s, there were few survivors before 28 weeks' gestation, and many more mature babies died from respiratory distress caused by absence of pulmonary surfactant.

#### **Survival rates**

With increasing and earlier use of antenatal corticosteroids, assisted ventilation, surfactant, and changing attitudes towards intensive care, survival rates for very preterm births, especially those born before 28 weeks' gestation, had improved strikingly by the 1990s (Saigal & Doyle, 2008). Furthermore, even infants admitted to neonatal intensive care for only short

periods of time or for less invasive care may still be at risk of negative neurodevelopmental outcomes, such as the late preterm subgroup of premature infants (McGowan, Alderdice, Holmes, & Johnston, 2011). These unique populations are now surviving into adolescence and adulthood, leading to the need for further explanation of the long-term consequences of various preterm birth weights.

Although ELBW and VLBW infant mortality rates in the United States decreased substantially in the 1980s and early 1990s, most reports fail to demonstrate further progress in reducing neonatal morbidity and mortality rates (Fanaroff et al., 2007). Between 2000 and 2009, a high proportion of infants born 501-1500 grams still either died or survived after experiencing at least one major neonatal morbidity known to be associated with both short- and long-term adverse consequences (Horbar et al., 2012). Biologically, preterm infants are more susceptible than their term counterparts because although most organs are immature, the brain and lung are especially susceptible to the consequences of preterm birth, which leads to high rates of long-term neurological and health problems (Saigal & Doyle, 2008), such as cerebral palsy and serious intellectual disability (IQ <55) (Salt & Redshaw, 2006). Those suffering from these serious disabilities likely have difficulties engaging in desired leisure time activities.

### **Prevalence of children born ELBW and late preterm**

Preterm deliveries are those that occur at less than 37 weeks' gestational age. In the United States, the preterm delivery rate is 12-13%; in Europe and other developed countries, reported rates are generally 5-9% (Goldenberg, Culhane, Iams, & Romero, 2008). The preterm birth rate has risen in most industrialized countries, with the United States rate increasing by more than one-third from 9.5% in 1981 to 12.7% in 2005 (B. E. Hamilton, Martin, & Ventura,

2013). This increase occurred despite advancing knowledge of risk factors and mechanisms related to preterm labor and the introduction of many public health and medical interventions designed to reduce preterm birth.

More recently, however, according to the National Vital Statistics Report, the preterm birth rate (the percentage of births delivered at less than 37 completed weeks of gestation) fell for the sixth straight year in 2012 to 11.54%, down 2% from 2011, and 10% from 2006 (B. E. Hamilton et al., 2013). Declines from 2011 to 2012 were seen among both early preterm (less than 34 completed weeks of gestation) and late preterm (34-36 completed weeks) deliveries. The early preterm rate was 3.41% in 2012, down from 3.44% in 2011 and 3.66% in 2006. The late preterm rate declined from 8.28% to 8.13% from 2011 to 2012, and is down 11% from the 2006 high (B. E. Hamilton et al., 2013), but still account for up to 75% of all preterm births. Although some of these late preterm infants are not admitted for neonatal intensive care, the proportion of all infants admitted for neonatal intensive care attributable to this late preterm group is significant (McGowan et al., 2011). Despite the decreasing preterm birth rate, the ELBW and late preterm children born in the 1990s or early 2000s are a population that has unique health care needs, differing from the general population.

### **Health outcomes in children born ELBW and late preterm**

The medical field has brought advancements allowing for improvements in perinatal care, resulting in increased survival rates for children born very preterm and/or ELBW. However, children who are born very preterm are at increased risk for a range of adverse neonatal outcomes. These outcomes differ in short-term and long-term consequences, as well as degree of severity. In recent years, a number of investigators have recognized the importance of measuring



the impact of preterm birth across multiple domains (Gray, Petrou, Hockley, & Gardner, 2006). Not only is there focus on general health outcomes, but other outcomes, such as quality of life and self-reported perceptions of disability and limitations, are beginning to be of interest.

Disability can occur in the domain of neuromotor function, mental and psychomotor development, or sensory and communication function. A recent study found that about half of all ELBW survivors at 30 months of corrected age had disability present, with approximately one quarter meeting the criteria for severe disability (Wood, Marlow, Costeloe, Gibson, & Wilkinson, 2000). In the literature, rates of severe disability vary between 18 and 40% for those born at 25 weeks' gestation or later (Hack & Fanaroff, 1999). Much of this variation in outcome may be attributable to small samples, differing proportions of infants born in or outside the hospital, high rates of loss to follow-up, and the inconsistent classification of disability. Examples of short-term consequences of extreme prematurity include chronic lung disease (Lefebvre, J., & St Laurent-Gagnon, 1996), severe brain injury (O'Shea, Klinepeter, Goldstein, Jackson, & Dillard, 1997) and retinopathy of prematurity (Allen, Donohue, & Dusman, 1993). The late preterm group has particular concerns in the neonatal period, including an increased risk of mortality in comparison to term infants (McGowan et al., 2011). Furthermore, late preterm infants are at significant risk for increased morbidity including hypothermia, hypoglycemia, hyperbilirubinemia, respiratory distress, poor feeding, and nutritional compromise (McIntire & Leveno, 2008; Wang, Dorer, Fleming, & Catlin, 2004). As more information emerges, it is apparent that the pattern of disabilities has changed over time.

## **Neurodevelopmental disabilities**

In the early stages of outcome studies, much of the attention was focused on major neurodevelopmental disabilities. These disabilities have been defined as a group of heterogeneous conditions that share a disturbance in the acquisition of basic development skills in a chronologically appropriate manner. This broad definition may include motor impairment such as cerebral palsy, blindness, deafness, severe intellectual disability and developmental language impairments. The perspective of concerns regarding behavioral and psychological health in ELBW and late preterm children has shifted in recent years as more health care professionals have begun to consider a broader range of outcomes and concepts (McCormick, 1997; McCormick, Workman-Daniels, & Brooks-Gunn, 1996). Although there is some resolution of the earlier neurodevelopmental difficulties and problems caused by ill health at adolescence, newer concerns such as learning difficulties, behavioral problems, and growth deficits have surfaced that are no less challenging (Saigal, Pinelli, Hoult, Kim, & Boyle, 2003). The late preterm infants have also been found to be at increased risk of poor performance in standardized testing, and increased diagnoses of developmental delay in comparison to term infants (Dong & Yu, 2011; McGowan et al., 2011). These broader health outcomes will continue to emerge as this susceptible population ages.

## **Social/behavioral/psychological disorders**

Several meta-analyses of case-control studies between 1980 and 1990 found that school-aged children who were born very preterm or with ELBW exhibited both internalizing disorders (anxiety and social withdrawal) as well as externalizing problems (attention deficit hyperactivity disorder (ADHD), oppositional and disruptive behavioral disorders) compared with term peers.

De Jong (2012) concluded that late preterm children show more school problems, have lower IQ scores, and more behavior problems than their full term peers, with ADHD particularly reported. This may be due to their immature brain development at birth as neurological maturation is one of the factors influencing the development of attention capacities. Children who survived very low birth weight and ELBW born between 1990 and 2000 were also found to be prone to inattention, hyperactivity, and social skill difficulties (Farooqi, Hagglof, Sedin, Gothefors, & Serenius, 2007). Another study found that late preterm children suffered from many problem behaviors as well, such as poor positive affect, frequent negative affect, poor attention, and low self-confidence (de Jong et al., 2012). These social difficulties have been found to be no less challenging than the major disorders that can result from preterm birth.

### **Cardiovascular disorders**

More recently, limited research has been done investigating the differences in mean levels of cardiovascular risk factor variables between low birth weight and control groups during childhood and adolescent periods. One study by Frontini et al (2004) found small and not significant differences for most of the variables, except for the adverse levels of HDL cholesterol and LDL cholesterol in childhood and glucose in adolescence among the low birth weight group (Frontini, Srinivasan, Xu, & Berenson, 2004). Other studies have suggested links between low birth weight and these cholesterol disorders, which are known as components of insulin resistance or metabolic syndrome (Phillips et al., 1998). It has been suggested that severe morbidities in late childhood and adolescence, even chronic diseases such as hypertension, hyperlipidemia, and high level of blood glucose in adulthood, may be partly due to abnormal growth patterns in fetal and infant life (Cole, 2004; Dong & Yu, 2011). These cardiovascular

risk variables are important to consider as the ELBW and late preterm population already have significant health concerns.

### **Physical activity levels of children born ELBW and late preterm**

Recently, research has begun to focus attention on other health outcomes of extreme prematurity, including physical activity levels. Rogers et al (2005) found that ELBW teenagers had lower aerobic fitness capacity, grip strength, leg power, and vertical jump. These teenagers could do fewer push-ups, had less abdominal strength as measured by curl-ups, had less lower back flexibility, and had tighter hamstrings. They reported less previous and current sports participation, lower physical activity level, and poorer coordination compared with full-term control subjects. The ELBW teenagers were also found to have more difficulty with maintenance of rhythm and cadence (Rogers, Fay, Whitfield, Tomlinson, & Grunau, 2005). These are all possible consequences of decreased physical activity and could potentially make physical activity participation less enjoyable.

Another study examined the association between birth weight and leisure time physical activity. According to Anderson et al (2009), a reverse U-shaped association was found between birth weight and physical activity. There were lower probabilities of being active, when compared to the odds of engaging in leisure time physical activity among subjects in the reference category, apparent at birth weights <2.76 kg and >4.75 kg, when examined for men and women combined (Andersen et al., 2009). They found that this was evident among both men and women and the strength of the reverse U-shaped birth weight-leisure time physical activity association was similar in men and women.

Several other investigators reported that very low birth weight adolescents and young adults lead a less active physical lifestyle and have limited participation in sports and strenuous activities (Ericson & Kallen, 1998; Hack et al., 2002; Johnson et al., 2003). A reduction in muscle strength and physical working capacity among very low birth weight boys was reported by Ericson et al (1998). They speculated whether the lower scores on these measures were a result of extreme prematurity or possible sheltering by parents (Miles & Holditch-Davis, 1997), or reflected a preference by the ELBW individuals for a lower physically active lifestyle. As previously mentioned, it is difficult to know exactly which limitations might deter the ELBW and late preterm children from physical activity participation.

Motor coordination problems are common in children of low birth weight, as well as variations in muscle tone (Goyen, Lui, & Woods, 1998; Powls, Botting, Cooke, & Marlow, 1995). Parents of ELBW teenagers have reported more clumsiness and below average performance in sports (Saigal et al., 2003; Saigal, Stoskopf, Streiner, & Burrows, 2001) and in self-report studies, teenagers have reported more clumsiness and less athletic competence (Grunau, Whitfield, & Fay, 2003; Saigal, Lambert, Russ, & Hoult, 2002). Birth weight is positively associated with adolescent and adult lean body mass (Eriksson, Tynelius, & Rasmussen, 2008; Yliharsila et al., 2007) and muscle strength (Yliharsila et al., 2007). This could, in turn, lead to a direct association between birth weight and an active lifestyle.

### **Physical activity intensity**

The intensity of the activity has found to be important, as well. For example, one study found that very-low-birth-weight (<1500 g) young Finnish adults were active at a lower intensity while undertaking regular leisure time exercise compared to subjects born at term (Hovi et al.,

2007). Examining the intensity levels of physical activity, this study found that the highest percentage of the ELBW young adults reported walking (29.4%), while the term born group reported the highest percentage of brisk runners (32.5%). Engaging in any form of physical activity can be beneficial; however, regular participation in moderate-intensity physical activity has been associated with a reduced risk of premature death from any cause and from cardiovascular disease. As a result, it is important to assess intensity levels when evaluating physical activity participation.

### **Exercise capacity**

Individual involvement and success in the area of active play and sports are influenced by the ability to endure physical activity. This is generally referred to as the exercise capacity of the child and may be described as the amount of physical exertion one can sustain in a given activity (Clemm et al., 2012). Exercise capacity may be limited by the aerobic capacity, and it also depends on other factors such as neuromotor skills, attitudes, endurance, and sensory and cognitive functions as well as experience with the particular activity in question (Astrand, Rodahl, Dahl, & Stromme, 2003). Physical inactivity due to real or perceived limitations or weaknesses may by itself reinforce the negative attitude toward exercise, with long-lasting negative effects on exercise capacity (Kajantie et al., 2010; Vederhus, Markestad, Eide, Graue, & Halvorsen, 2010). Clemm et al (2012) found that although one may envision several developmental shortcomings that may interfere with exercise capacity (including neuromotor, muscular, sensory or cognitive deficiencies), the exercise capacity of subjects born ELBW was normal and in the same range as matched control subjects. They also noted that leisure-time physical activity was similarly and positively associated with exercise capacity in preterm and term-born adolescents alike, although participation was lower among those born preterm (Clemm

et al., 2012). Previous studies on exercise capacity after preterm birth report diverging results (Dahan-Oliel, Mazer, & Majnemer, 2012; Kilbride, Gelatt, & Sabath, 2003; Rogers et al., 2005), which may reflect real differences between the populations studied, but may also be a result of the differing test set-ups as those children born preterm differ from those born at term on a range of abilities that may influence results.

In conclusion, while it appears evident that extreme groups such as young adults born severely preterm exercise less than those born at term (Hovi et al., 2007; Saigal et al., 2007), studies assessing the association of birth size with physical activity in childhood (Hallal, Wells, Reichert, Anselmi, & Victora, 2006; Mattocks et al., 2008), as well as in adult life (Andersen et al., 2009), have been inconsistent. More studies are needed with groups of various birth weights to research the relationship between birth weight association and physical activity in children and young adults

### **Physical activity limitations of children born ELBW and late preterm**

Studies have documented limitations that preterm children have with physical activity (Farooqi et al., 2007; Hack, Taylor, Klein, & Mercuri-Minich, 2000; Johnson et al., 2003; Saigal et al., 2007). Even among mainstream ELBW teenagers, parents reported that the teenager's day to day lives were more likely to be limited by their physical health, both in terms of the kind of activities they could do and the amount of time they could spend on them compared with the control group (Johnson et al., 2003). Farooqi et al (2006) found that limitations included mental or emotional delay, blindness or difficulty in seeing, physical delay, restriction in activities, and trouble understanding simple instructions. This study noted that 21 preterm children, compared with four in the control group, needed to reduce their time or effort in activities. Of these, seven

tired easily because of poor motor skills and poor coordination, four reported cerebral palsy as the reason, six reported visual problems, three reported attention deficit hyperactivity problems, and one reported deafness. The overall rate of one or more functional limitations was significantly higher in the preterm cohort, with the most common functional limitation in the preterm children being mental or emotional delay, regardless of neurosensory impairment (Farooqi et al., 2007). These numerous limitations appear to have an impact on physical activity participation.

Other studies have reported differing physical activity limitations. Hack et al (2002) noted that children weighing <750 g at birth, when compared with the children born at term, had significantly higher rates of physical growth delay, mental or emotional delay, inability to participate in sports or physical activities and blindness or difficulty seeing (Hack et al., 2002). In a similar study, Saigal et al (2001) found that ELBW adolescents had a significantly higher prevalence of functional limitations by parent report in most domains. Developmental delay, clumsiness, emotional problems, learning difficulties, and visual problems were much more prevalent than in control participants. A third of the ELBW adolescents had limitations in their ability to participate in normal activities at school, extracurricular activities and/or other activities that are normal for age compared with only 9% of control participants (Saigal et al., 2001). Reported limitations are important in assessing general health outcomes as well as impact on physical activity levels.

### **Personality traits**

Other possible limitations to participation in physical activity have been noted by researchers. Preterm infants tend to have personality traits that may contribute to the lower



levels of physical activity. Low birth weight adults show more risk avoidance (Hack, Cartar, Schluchter, Klein, & Forrest, 2007), are more shy, cautious, and unassertive (Pesonen et al., 2008; Schmidt, Miskovic, Boyle, & Saigal, 2008) and, are anxious and withdrawn (Miles & Holditch-Davis, 1997). Grunau and colleagues (2003) have found that teens born with ELBW demonstrated less confidence in their abilities to participate in athletics, excel in school achievement, have romantic relationships, and demonstrate job competencies. These personality traits may affect the ELBW teenagers desire to participate in regular, routine physical activity.

### **Biological factors**

It has also been proposed that low birth weight could be associated with a reduced physical capacity through a variety of biological mechanisms, including a reduced muscle strength because of low muscle mass (Eriksson et al., 2008; Yliharsila et al., 2007) that can also be measured as reduced hand grip strength (Yliharsila et al., 2007). These biological factors could reduce the willingness to undertake physical activity because of early tiredness and a reduced ability to perform physical activity (Andersen et al., 2009). Perhaps encouraging non-competitive, more regular forms of physical activity would help to minimize these factors.

In summary, lower birth weight has been associated with reduced physical performance, including muscle strength (Yliharsila et al., 2007), muscle endurance (Ridgway et al., 2008) and aerobic fitness in both childhood and adulthood (Ridgway et al., 2008) and it has been suggested that this lower physical capacity may lead to reduced levels of physical activity (Andersen et al., 2009). However, some studies have found that adolescents who were born ELBW noted self-competency levels that were not significantly different from controls or normative data on social, scholastic, or athletic competencies (K. J. Brown, Kilbride, Turnbull, & Lemanek, 2003; Clemm

et al., 2012). They considered themselves healthy and well adjusted, in spite of apparent neurosensory and academic impairments, with parents generally positive about their children's outcome and the present impact of the youth on family life.

### **Health outcomes of physical activity**

Observational studies provide compelling evidence that regular physical activity and a high fitness level are associated with a reduced risk of premature death from any cause and from cardiovascular disease in particular among asymptomatic men and women (S. N. Blair et al., 1995; Oguma & Shinoda-Tagawa, 2004). Furthermore, a dose-response relation appears to exist, such that people who have the highest levels of physical activity and fitness are at lowest risk of premature death (Warburton, Nicol, & Bredin, 2006). The American College of Sports Medicine (ACSM) recommends children and adolescents ages 6-17 years to achieve 60 minutes or more of moderate-intensity physical activity each day. The ACSM also recommends adults to accumulate 150 minutes per week of moderate-intensity physical activity (Garber et al., 2011). Regular physical activity has been shown to be effective in the secondary prevention of cardiovascular disease and is effective in attenuating the risk of premature death among men and women. It can improve musculoskeletal fitness, which has increasing evidence to be associated with an improvement in overall health status and a reduction in the risk of chronic disease and disability (Warburton, Gledhill, & Quinney, 2001). These benefits of regular physical activity have been well-documented in a variety of populations and disease states.

There are several biological mechanisms that may be responsible for the reduction in risk of chronic disease and premature death associated with regular physical activity. For example, regular physical activity has been shown to improve body composition, enhance lipid lipoprotein

profiles, and improve glucose homeostasis and insulin sensitivity (Warburton et al., 2001; Warburton et al., 2006). Regular physical activity also has been shown to reduce blood pressure (S. Blair, Goodyear, Gibbons, & Cooper, 1984), improve autonomic tone (Tiukinhoy, Beohar, & Hsie, 2003), reduce systemic inflammation (Adamopoulos et al., 2001), decrease blood coagulation, and enhance endothelial function (Gokce et al., 2002). It is also associated with improved psychological well-being. These mechanisms are particularly important for the prevention and management of cardiovascular disease, but it also has important implications for the prevention and management of other chronic diseases such as diabetes, osteoporosis, hypertension, obesity, cancer and depression.

### **Sedentary behaviors of children born ELBW and late preterm**

While the physical activity patterns of preterm and low birth weight children are fairly well-established, the sedentary behaviors of these children are not as well documented. Only recently has the interest begun to shift to include sedentary behavior data to evaluate its effects on health outcomes.

As reported, ELBW young adults continue to suffer from chronic health conditions, and significantly higher proportions have functional limitations. For these various reasons, ELBW young adults seem to lead a more sedentary lifestyle than their peers (Saigal et al., 2007). One study found that ELBW children have a lower level of fitness, as measured by a maximal oxygen consumption treadmill test, compared with normal birth weight children, and the parents of ELBW children also identified their teenagers as being less active than the normal birth weight group (Kilbride et al., 2003). The less active lifestyle, when occurring on a regular basis, can lead to a variety of health outcomes that will be discussed in the next section.

Poor early coordination combined with low self-confidence may contribute to lack of establishment of healthy levels of physical activity in childhood as well as lack of common knowledge of and skills for group sports and activities (for example, how to swim, catch a ball, etc). This carries into young adulthood, contributing to poor self-image and lack of association with more socially and physically active peers. This may add to the overall tendency of ELBW teenagers to be more sedentary compared with their peers (Rogers et al., 2005). Also, early motor development is an important predictor of adult physical performance, with adolescents or adults born at low birth weights characterized by poorer motor coordination and lower perceived physical ability (Saigal et al., 2007). The lower lean body mass, muscle strength, and exercise capacity also present from childhood may make physical activity less rewarding (Kajantie et al., 2010). It is important for children and adolescents to feel confident in their ability to participate in regular physical activity, as this may aid in decreasing sedentary behaviors and lifestyles.

Interestingly, one study noted that the majority of children with sedentary lifestyles belonged to the lowest birth weight group, but the association between birth weight and life style was not statistically significant (Hallal et al., 2006). This study examined adolescents aged 10-12 years and noted that the lowest birth weight group (<2500 g) had the highest percentage of sedentary lifestyles (61.9%), while the highest birth weight group (>3500 g) had the lowest percentage of sedentary lifestyles (57.5%). These authors suggested that genetic factors or habit formation during early childhood seem to be of greater importance in determining physical activity than physiological factors as consequences of programming.

### **Health outcomes of sedentary behavior**

Most health professionals agree that moderate-to vigorous-intensity physical activity has an established preventive role in cardiovascular disease, type 2 diabetes, obesity, and some cancers. However, recent epidemiologic evidence suggests that sitting time has deleterious cardiovascular and metabolic effects that are independent of whether adults meet physical activity guidelines (M. T. Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). There is new evidence on the importance of avoiding too much time in sedentary behaviors (primarily sitting and other activities that involve low levels of metabolic energy expenditure) and the biologic mechanisms that underlie these associations (M. T. Hamilton, Hamilton, & Zderic, 2007). Sitting too much is not the same as lack of exercise and, as such, has its own unique metabolic consequences (M. T. Hamilton et al., 2007). As such, it is important to not only assess the physical activity levels, but also the sedentary behaviors to establish anticipated health outcomes of a specific population. Knowing how little or how much physical inactivity adolescents and young adults engaged in, from a behavioral perspective, only provides half the answer. The other half concerns what they are actually doing while they are sedentary (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004). ELBW and late preterm survivors often suffer from impairments that could limit involvement in physical activity and lead to preference of sedentary behaviors; these established health consequences of sitting too much are of high importance and should not be ignored.

### **Screen Time**

American children spend more time watching television (TV) and videotapes and playing video games than doing anything else except sleeping (Stanger & Center, 1997). Two primary mechanisms by which screen time contributes to obesity and other undesirable health outcomes

have been suggested: reduced energy expenditure from displacement of physical activity and increased dietary energy intake, either during viewing or as a result of food advertising (Robinson, 1999).

Early evidence for the displacement of physical activity by screen time came from studies documenting decreases in participation in physical activities following the introduction of TV into small, mainly rural, communities (J. Brown, Cramond, & Wilde, 1974; Williams, 1986). However, more recent epidemiologic studies of the relationship between activity level and TV and video game use among children and adolescents have been inconsistent (Vandewater, Shim, & Caplovitz, 2004). For example, a study from Marshall et al (2002) would find that certain sedentary behaviors, such as TV viewing, are not necessarily obstacles to physical activity, contrary to popular belief. The so called ‘displacement hypothesis’, whereby screen time or other sedentary behaviors are thought to displace physical activity (Mutz, Roberts, & Van Vuuren, 1993) may not be accurate. Biddle et al (2004) concluded that while watching TV is inevitably prohibitive of physical activity at that time, one should not assume that the behavior of TV viewing is therefore inversely correlated with physical activity over the whole day, week or month (Biddle et al., 2004). Additionally, only a few epidemiological studies have found weak inverse associations between hours of TV viewing and physical activity (DuRant, Baranowski, Johnson, & Thompson, 1994; Robinson et al., 1993) and fitness (Robinson, 1999). This is consistent with the finding that reductions in TV, computer, movie, and video game use did not result in compensatory increases in other sedentary pursuits.

A growing number of studies indicate that the obesogenic effect of screen time in young people may be attributed more to increased food intake than to decreased physical activity levels. In fact, adolescents or families who watch TV excessively are less likely to eat fruit and

vegetables (Campbell, Crawford, & Ball, 2006; Vereecken, Todd, Roberts, Mulvihill, & Maes, 2006), and are more likely to eat sweets (Campbell et al., 2006; Vereecken et al., 2006), soda (Coon, Goldberg, Rogers, & Tucker, 2001) and soft drinks (Campbell et al., 2006; Ng, Young, & Corey, 2010; Vereecken et al., 2006). One mechanism by which excessive screen time may lead to the adoption of unhealthy dietary habits could be the higher exposure time to food commercials, which advertise energy-dense products with lower nutritional value. Families may prefer screen time during their leisure time as it is an inexpensive behavior (Rey-López et al., 2011). Rey-Lopez (2011) found that energy-dense dietary choices were more likely in adolescents who watched TV excessively (>2 hours per day). Continually making energy-dense dietary choices may cause unfavorable changes in a population that is already at risk for metabolic conditions and cardiovascular complications.

### **Primary theoretical frameworks**

#### **Parental Overprotection**

There is little use of theoretical frameworks in the area of ELBW, late preterm, or low birth weight populations in regards to physical activity and sedentary behaviors. However, there are many studies suggesting the idea that parental behaviors, such as parental protection or monitoring during childhood and adolescence, prevent children from participating in physical activity as recommended. Parental overprotection may not only contribute to developing personality, but may also directly reduce physical activity (Kajantie et al., 2010). Another study noted that low birth weight adults characterize their parents as having been more controlling and protective (Pyhala et al., 2009). These characteristics of over-protective parents may directly

influence the lifestyle choices of their children, potentially impacting their physical activity choices.

Parental overprotection, first described by Levy in 1931, was considered to be expressed in four ways: excessive physical or social contact (e.g., continuous companionship and extended co-sleeping), prolonged infantilization (e.g., routine assistance with feeding, dressing, and toileting, despite the child's ability to perform such tasks autonomously), active prevention of independent behavior and social maturity (e.g., delaying school entry or allowing the child to play only within the mother's sight), and dominating excess of maternal control (e.g., a rigid overregulation of the child's behavior) (Thomasgard, Metz, Edelbrock, & Shonkoff, 1995). Wightman et al (2007) examined the relationship of parental protection scores with ELBW children and normal birth weight eight-year olds. They found significant factors associated with the presence of parental overprotection, which were caregiver unmarried status, education less than high school, residence in a neighborhood with a poverty level above 30%, and depression (Wightman et al., 2007). Child-related factors associated with higher rates of overprotection included singleton birth, oxygen requirement at 36 weeks corrected age and neurosensory impairment, subnormal IQ, poor adaptive behavior and a higher number of functional limitations and special health care needs.

Child personality may also be affected by parental over-protection. Blake et al (1975) examined the relationship of parent protection and prematurity and found parents to be overprotective and highly anxious. They postulated that this could account for the overdependence, anxiousness, and shyness reported in these children (Blake, Stewart, & Turcan, 1975). As previously mentioned, there have been internalizing disorders, such as anxiety and



social withdrawal, established in ELBW children. This relationship may be connected to parental overprotection, as well.

Overall, there is very little information regarding parental overprotection among preterm children, many of whom have chronic conditions (Hack et al., 2011; Johnson et al., 2003). However, the increased survival of low birth weight children and the health care needs in recent survivors may predispose them to increased parental protection (Wightman et al., 2007). Longer term follow-up is needed to evaluate whether the increase in parent protection may foster overdependence, impair the child's ability to participate in physical activity, and encourage favoring of sedentary behaviors.

For clinicians, the promotion of physical activity and reduction of sedentary behaviors must be emphasized to parents. Perhaps if overprotective parents of ELBW children and adolescents are taught accurate information regarding the safety of participating in physical activity and its importance on long-term health consequences, they may encourage a more active lifestyle. Lower degrees of physical activity throughout childhood and adolescence may lead to a self-perpetuating effect on these characteristics, which persist to adulthood (Hovi et al., 2007; Rogers et al., 2005; Saigal et al., 2007). Recommendations for early intervention of former ELBW youths and teenagers should include encouragement to be active and participate in noncompetitive physical activities with family and peers (Rogers et al., 2005). This should contribute to the establishment of a foundation for a healthy, active lifestyle that will support establishing relationships, social skills, and self-confidence in this vulnerable population. As children and families attend follow-up visits, the promotion of healthy lifestyle, in particular physical activity and limiting sedentary behaviors, should be a key component of the follow-up for ELBW and late preterm children. The greatest improvements in health status are seen when

people who are least fit become physically active, as health promotion programs should target people of all ages, since the risk of chronic disease starts in childhood and increases with age (Warburton et al., 2006). ELBW and late preterm children would clearly benefit from their clinicians encouraging regular physical activity, as this is a crucial piece to establishing lifelong healthy habits.

### **Problems and issues arisen in the study area**

Although differences have been noted between ELBW and late preterm children, and term-born controls, it is difficult to know if observed differences are attributable to fundamental variances as a result of extreme prematurity (for example, cardiorespiratory, muscular, or neurobiological compromise) or if these findings partly or predominantly reflect the lower physical activity lifestyle that the ELBW teenagers choose (Rogers et al., 2005). Moreover, many physical activity and sedentary time studies exclude those ELBW teens with serious neurosensory impairments, so these results may not be generalizable to the complete ELBW survivor population, as the objective of these studies are to compare ELBW teens that were free of impairment with those with who they would be competing in the adult world. By excluding those ELBW survivors with severe disability, studies may often overestimate the abilities of the overall population of ELBW teenagers and young adults. Furthermore, historically, studies that involve physical activity evaluation to assess aerobic performance in ELBW subjects have limited study sample sizes. A recent review article noted ranges between 12-33 preterm children in the study group as compared to term-born control subjects (Hebestreit & Bar-Or, 2001; Kilbride et al., 2003). There also has been a limited amount of studies done that examine adolescent and young adult physical activity participation, with Dahan-Oliel (2012) reporting only eight recent studies strong enough to be included in a literature synthesis (Gardner et al.,

2004; Hovi et al., 2007; Johnson et al., 2003; Kajantie et al., 2010; Kilbride et al., 2003; Rogers et al., 2005; Saigal et al., 2007).

Late preterm newborns have been historically managed as term neonates because of their relatively large size and seemingly mature appearance (Dong & Yu, 2011). A growing body of evidence suggests that the incidence of medical problems is higher among late preterm infants than term infants (de Jong et al., 2012; McGowan et al., 2011), and seemingly mature late preterm infants should be considered physiologically immature and should be carefully evaluated, monitored and followed. The late preterm infants constitute an epidemiologically significant group of preterm infants and neonatal intensive care graduates, but the extent of adverse developmental outcomes in their adolescent and young adult years remain largely under researched (McGowan et al., 2011). McGowan et al (2011) noted that although late preterm infants were previously considered similar to term infants, emerging evidence suggests that significant adverse outcomes do exist among late preterm infants, which further indicates that longer-term outcomes of prematurity remain a concern even for those born at the more optimistic late preterm stages of pregnancy (McGowan et al., 2011). Additionally, follow-up into late adulthood is essential to determine whether the chronic health conditions and functional limitations among ELBW and late preterm young adults will get progressively worse with age and whether they will have a higher prevalence of cardiovascular disease and metabolic problems in the future. In a larger context, there is currently a lack of information in the United States general population regarding the effects of low birth weight on the longitudinal trends in the cardiovascular risk factor variables measured serially and concurrently from childhood to adolescence.

### **Summary of literature review**

Participation in regular physical activity is a contributor to good overall health, whereas inactivity and poor physical fitness are now recognized as significant health risks. Lack of physical activity is a significant contributor to the increasing rate of childhood obesity in developing countries. Establishing early, adequate levels of fitness and activity may be particularly important in former ELBW and late preterm infants, who may be at risk for early – onset adult diseases such as diabetes, hypertension, ischemic heart disease, and strokes (Rogers et al., 2005). While there are consistent observations that late preterm infants have more favorable outcomes than very preterm or ELBW infants, they have less favorable outcomes than term infants. There also appears to be a continuous relationship between decreasing gestational age and increasing risk of adverse outcomes such as neurodevelopmental disabilities and academic performance (McGowan et al., 2011). Studies worldwide, regardless of socio-economic background, have linked low birth weight to increased risk of insulin resistance, dyslipidemia, hypertension, coronary heart disease, and type 2 diabetes. Increasing physical activity and decreasing sedentary behaviors may be of particular benefit to those with low birth weight by reducing metabolic risk.

There is evidence showing that low birth weights outside the normal range of birth weights are associated with a lower probability of being physically activity during leisure time. This may be part of the underlying mechanism of the association between birth weight and disease and may thus have public health implications (Andersen et al., 2009). The theory of parental overprotection for ELBW and even potentially late preterm children should be further examined so as to help educate the parents on the importance of physical activity promotion in their children.

The new perspective on the deleterious health consequences of too much sitting should be seen as being additional to, and not as an alternative to, the well-recognized benefits of participation in health-enhancing moderate-intensity physical activity (M. T. Hamilton et al., 2008). Although studies have looked at the physical activity patterns, few have studies sedentary behaviors of ELBW and late preterm adolescents. The accurate assessment of the physical activity patterns and sedentary behaviors of ELBW and late preterm children is important information for clinicians and family members. Investigating these two components together will allow for clinicians to better understand preterm and low birth weight children health outcome's impact on their levels of physical activity and sedentary behavior. Additionally, late preterm infants have a lack of research on adverse developmental outcomes in their adolescent and young adult years, with further information needed to determine if management of this distinctive group should be altered. This will allow for establishment of the need for future intervention, adoption of healthy behaviors and overcoming barriers for these unique and vulnerable populations.

## **Chapter III**

### **Methods**

#### **Purpose**

The purpose of this study was to determine whether or not the self-reported physical activity levels and preferences of physical activities of unimpaired ELBW and late preterm adolescents differed significantly from full-term control adolescents. Additionally, physical activity characteristics were further examined by comparing the self-reported physical activity levels with measured peak oxygen consumption. Self-reported leisure-time sedentary behavior characteristics and screen time usage (television, computer, and video games) were also examined.

#### **Research Design**

This study was designed to evaluate secondary data consisting of two questionnaires specifically examining physical activity levels and sedentary behaviors, as well as measured peak oxygen consumption, of ELBW, late preterm, and full-term control adolescents. Original data collection utilized a cross-sectional survey research design, which is research that is collected at a single point in time (Johnson & Christensen, 2008). The research design was also considered to be non-experimental as there were no manipulations of the independent variables or utilization of random assignment to groups. This design was appropriate for the study as it provided ease of obtaining survey based and measured data to describe the current physical activity levels and sedentary behaviors of ELBW, late preterm, and full-term adolescents.

## **Review of Literature**

An extensive literature review was performed focusing on physical activity and sedentary behaviors of ELBW and late preterm adolescents. Research was reviewed from the 1990's to the present, as this is a relatively new area of interest for outcomes regarding preterm infants. Upon selection of the research design, the study was approved by the Human Subjects Lawrence Committee at the University of Kansas and the Children's Mercy Hospital Institutional Review Board.

## **Subject/Site Selection Procedures**

This study included adolescents from a convenience cohort of children born at Saint Luke's Hospital and Truman Medical Center, in Kansas City, Missouri during the years January 1993 to December 1995. These hospitals were selected as they are University of Missouri Kansas City teaching hospitals with perinatal delivery services.

There were three groups of adolescents in this study: ELBW with birth weight < 800 grams and gestational age < 37 weeks, late preterm with birth weight 1501-2500 grams and gestational age < 37 weeks, and full-term with birth weight >2501 grams and gestational age >37 weeks. The children in this study were formerly evaluated in a Children's Mercy Hospital multidisciplinary follow-up study to six years of age, which included 41 ELBW children, 42 late preterm children, and 26 full-term control children. Additional full-term children were recruited in an attempt to equalize the study groups, fitting all previous inclusion criteria except they were not part of the original multidisciplinary follow-up study. Subject selection and matching for the original study was done by reviewing the birth registry from the hospitals following admission of the ELBW infant. The next two surviving infants were selected that fit the specified birth weight

and gestational age criteria and were of the same gender as the ELBW infant. From the original cohort, 48 of the previously evaluated children did not participate in the current study for the following reasons: ten of the children (4 ELBW, 3 late preterm, 3 full-term) did not wish to participate in the study, and 38 of the children (12 ELBW, 14 late preterm, 12 full-term) were lost to follow up. Demographic data including gestational age, birth weight and gender of the current study's participants were compared to the original cohort to ensure generalizability to the larger population. Additional participants were recruited; however, children were excluded from the study because of cognitive delay ( $IQ \leq 84$ ), cerebral palsy, or other neurodevelopmental impairments by testing at five to eight years of age due to the nature of the testing relying on individual understanding and cooperation and to ensure safe participation in the study. This study consisted of 17 ELBW subjects, 21 late preterm subjects, and 23 full-term control subjects, with sample sizes comparable to those seen in current literature. A recent review article noted that studies evaluating aerobic performance in ELBW subjects have limited sample sizes, with approximately 12-33 preterm children in the study groups when compared to full-term control subjects (Hebestreit & Bar-Or, 2001; Kilbride et al., 2003). This study consisted of subjects between 12-20 years of age at the time of testing.

### **Data Collection Procedures**

Upon arrival to the hospital, the child and parent (if child was under age 18) were taken to an exam room where the informed consent discussion took place. Prior to the visit, the permission form was mailed to the families to allow adequate time to read the form. Any additional questions were addressed during the informed consent process.



All ELBW, late preterm and full-term subjects received the same battery of tests and questionnaires. The families participated in one testing session (lasting approximately 60-90 minutes), that included pulmonary function testing, exhaled nitric oxide testing, peak oxygen consumption treadmill exercise testing, and questionnaire assessments. Additional results on the exhaled nitric oxide testing and treadmill exercise testing can be found in this previously published article (Kilbride, Gelatt, & Sabath, 2003). All questionnaire data for this study were collected by surveys administered by the study coordinator, interviewing both the parent and child prior to exercise testing. The peak oxygen consumption data were collected by utilizing a maximal treadmill exercise test performed by two trained pediatric exercise physiologists in the Exercise Physiology Lab at Children's Mercy Hospital in Kansas City, Missouri.

Demographic data were evaluated for further understanding of the study sample population to allow for appropriate generalizability of the study results. These demographic characteristics included gender, race, gestational age, birth weight, as well as age, height and weight at the time of testing. Additional characteristics that were documented included any current treatment for asthma, hospitalizations in the past two years, and reported exercise complications, such as dizziness or chest pain with exercise.

The subjects were given \$50.00 cash following completion of the battery of tests as a payment for time and inconvenience of participation, such as compensation for time off work. All data from the tests were gathered and maintained by the study coordinator and entered into a spreadsheet for further analysis. Subjects were assigned a unique study number with all unique subject identifiers removed. Data were maintained in a password protected spreadsheet on the secure terminal server at Children's Mercy Hospital with only primary investigators and study coordinators having access to the data.

## Testing Instruments

**Modifiable Activity Questionnaire for Adolescents.** The Modifiable Activity Questionnaire for Adolescents (MAQ) was developed by Kriska (1990) as an instrument to measure adolescent physical activity that is both accurate and practical for use in epidemiologic research (Aaron et al., 1995). A modification of the MAQ was utilized in this study to evaluate the past year leisure-time physical activity (See Appendix A, Modifiable Activity Questionnaire). Past-year activities were assessed to obtain the most accurate picture of the individual's usual activity level, as activity surveys with a short time frame may not reflect normal physical activity over a longer period because of seasonality, acute illness, or other causes of short-term variability of activity (Kriska et al., 1990).

The survey utilized in this study was a modification of the MAQ, which has data regarding validity and reliability. Aaron et al (1995) noted that overall, the reproducibility coefficients were found to be quite high, indicating excellent long-term and short-term reproducibility (Aaron et al., 1995). This study also found that the estimates of the physical activity obtained from the past year questionnaire completed at the completion of the study were found to be significantly correlated with their reference method, providing evidence that the past year questionnaire was reflective of habitual physical activity levels of adolescents. In another study, the physical activity measured by a motion sensor correlated significantly with total hours of physical activity for the past year measured by the MAQ ( $r=0.40$ ,  $p=0.04$ ) (Nixon, Orenstein, & Kelsey, 2001). Significant test-retest reliability was observed with administration of the MAQ initially and 3 months later. Intraclass correlation coefficients were 0.77, 0.70, and 0.58 for total hours, MET hours, and vigorous activity hours per week, respectively, for the past year (Nixon et al., 2001).

*Past year leisure-time physical activity.* Past year leisure-time physical activity was assessed from a list of 30 activities. Subjects indicated activities that included participation of at least five times in the past year, including all sport teams participation during the last year. Activities were not included if they were time spent in school physical education classes. Activities listed on the MAQ and their corresponding MET levels are as follows:

- Aerobics – 5.0 METs
- Band/drill team – 4.0 METs
- Baseball – 3.5 METs
- Basketball – 7.0 METs
- Bicycling – 6.0 METs
- Bowling – 2.5 METs
- Cheerleading – 4.5 METs
- Dance class – 4.5 METs
- Football – 7.5 METs
- Garden/yard work – 4.0 METs
- Gymnastics – 6.0 METs
- Hiking – 6.0 METs
- Ice skating – 6.0 METs
- Roller skating/blading – 6.0 METs
- Running for exercise – 10.0 METs
- Skateboarding – 6.0 METs
- Snow skiing – 9.0 METs
- Snowboarding – 9.0 METs
- Soccer – 8.0 METs
- Softball – 3.5 METs
- Street hockey – 8.0 METs
- Swimming (laps) – 8.0 METs
- Swimming (play) – 4.0 METs
- Tennis – 6.5 METs
- Trampoline jumping – 4.0 METs
- Volleyball – 3.0 METs
- Water skiing – 7.0 METs
- Weight training – 5.0 METs
- Wrestling – 8.0 METs
- Others (such as yoga or jump rope)

Subjects were read the list of common leisure activities provided, and asked to indicate the activities that they had engaged in at least five times during the past year (12 months). They could also report activities not included on the list. For each activity indicated, they were asked to provide detailed information on the number of months, number of times per week, and the average duration of participation (recorded as hours per time) for each activity. The total hours

of activity were summed and expressed as an average of the total hours of activity per week for the past year. For each activity, a crude estimate of its relative intensity was derived by multiplying the average hours per week by the metabolic cost of that activity that was obtained from published tables (Katch & McArdle, 1988; Passmore & Durnin, 1955; Wilson, Paffenbarger Jr, Morris, & Havlik, 1986; Ainsworth et al., 2000) and expressed as MET hours per week. The outcome variable was the average total MET hours per week for the past year.

*Preferences of physical activities.* Preference of physical activities were obtained from the list of activities that the subject had engaged in at least five times during the year (indicated by the subject when completing the past year leisure-time physical activity portion of the MAQ). The MET level for each physical activity indicated by the subject was determined utilizing previously published tables and the Compendium of Physical Activities as a resource to estimate and classify the energy cost of human physical activity (Ainsworth et al., 2000). Subjects that did not indicate any physical activities in the past year were considered to be sedentary with a corresponding MET level of less than 1.5. Light intensity physical activities are considered to be any physical activity not hard enough to make you breathe heavily and make your heart beat fast, including activities such as walking or slow bicycling with a MET value of 1.6-3.0 METs. Moderate intensity physical activities are considered to be any physical activity that is difficult enough to noticeably elevate heart rate while still able to carry on a conversation, including activities such as brisk walking or weight training with a MET value of 3.1-6.0 METs. Hard intensity physical activities are considered to be any physical activity that is difficult enough to cause heavy breathing and fast heart rates, including activities such as playing basketball, jogging, or fast bicycling with a MET value of greater than 6.1 METs. The outcome variables

were the number of light, moderate, and hard physical activities indicated by the subject on the past year average leisure-time physical activity portion of the MAQ.

**Treadmill Exercise Testing.** An incremental treadmill test was performed using a Children's Mercy Hospital Max (CMH Max) protocol, identical in all subjects (see Table 3-1, CMH Max treadmill protocol). The CMH Max protocol is a ramp treadmill protocol designed specifically for use with the pediatric population. The treadmill was chosen as the mode of exercise because walking and running are familiar to most adolescents and are also highly relevant for daily life, as opposed to cycling, which some children may not be comfortable with. The treadmill exercise test was performed to estimate the relative peak oxygen consumption (expressed as ml/kg/min) of the subject. The peak oxygen consumption is the maximum rate of oxygen consumption as measured during incremental exercise, reflecting the aerobic physical fitness of the individual, and is an important determinant of their endurance capacity during prolonged, sub-maximal exercise.

The CMH Max ramp protocol consists of gradual speed and elevation increases every 60 seconds from an initial walking warm-up stage of 3 minutes. After a brief warm-up of very slow walking for one to two minutes for orientation to the treadmill, subjects were instructed to exercise to exhaustion wearing a face mask of appropriate size connected to a two-way non-rebreathing valve (Hans Rudolph, Kansas City, MO). The treadmill maximal exercise test was performed utilizing the Quinton Q-Stress 4000 system (Cardiac Science Corporation, Bothell, WA) with continuous electrocardiogram monitoring. Oxygen consumption was measured with a ParvoMedics (Salt Lake City, Utah, USA) TrueOne 2400 breath-by-breath oxygen analyzer which also analyzes minute ventilation, tidal volume, respiratory exchange ratio (RER), oxygen pulse, and ventilatory anaerobic threshold. Criteria for determining if maximal effort was given

during the treadmill test included attainment of a near-maximal peak heart rate, an  $\text{RER} \geq 1.0$ , and subjective appearance of the patient such as ataxia, indicating adequate exercise effort (Rowland, 1993).

Although data on validity and reliability for the protocol used in this study to assess maximal oxygen consumption are not available, research indicates that ramp protocols increase work rate in a constant and continuous manner, and are very efficient in providing exercise responses in a short amount of time, thus enabling acquisition of diagnostic data within ten to twelve minutes (Cooper, Weiler-Ravell, Whipp, & Wasserman, 1984; Felsing, Brasel, & Cooper, 1992; Paridon et al., 2006). The advantages of the ramp protocol, over more traditional incremental treadmill protocols, such as the Bruce, Ellestad or Naughton, allow for enhancing diagnostic performance, provide a more accurate estimate of exercise capacity, and improve utility of exercise testing for predicting prognosis in a clinical setting (Myers & Bellin, 2000). Additionally, normative data on 785 exercise tests analyzing peak heart rates (beats per minute), peak blood pressure (mmHg), total exercise time, and METS (metabolic equivalents) achieved found that the CMH Max protocol produced peak cardiorespiratory parameters that were equal to or greater than the values observed for the Bruce protocol in adolescent cardiology patients. Preliminary results suggest that the CMH Max protocol is a viable alternative to the Bruce protocol in the evaluation of pediatric population (Sabath, Teson, Hulse, & Gelatt, 2012).

**Table 1:** *CMH Max treadmill protocol (one minute stages)*

Stage	Speed (mph)	Grade (%)	METs
Stage 1	3.0	0	3.3
Stage 2	3.0	0	3.3
Stage 3	3.0	0	3.3
Stage 4	4.0	0	4.8
Stage 5	4.0	2.5	6.0
Stage 6	4.0	5.0	7.2
Stage 7	5.0	5.0	10.3
Stage 8	5.5	5.0	11.3
Stage 9	6.5	5.0	13.1
Stage 10	7.0	5.0	14.1
Stage 11	7.0	7.5	15.3
Stage 12	7.5	7.5	16.3
Stage 13	8.0	7.5	17.3
Stage 14	8.5	7.5	18.3
Stage 15	8.5	10.0	19.8
Stage 16	9.0	10.0	20.9

**Sedentary Behavior Questionnaire.** The Sedentary Behavior Questionnaire (SBQ) utilized in this study was developed by Dr. Patricia Nixon (Wake Forest University) as an instrument to estimate the amount of time children spend in sedentary behaviors (See Appendix B, Sedentary Behavior Questionnaire). The questions on the SBQ were utilized in the analysis to evaluate the self-reported sedentary behaviors during the week and on the weekend days.

The SBQ was adapted from a measure used in children that has some evidence of reliability and validity and has been used in a variety of populations (Norman, Schmid, Sallis, Calfas, & Patrick, 2005; Robinson, 1999; Robinson & Killen, 1995). A study by Norman et al (2005) utilized a similarly adapted SBQ and found the internal consistency to be moderate with  $\alpha = 0.59$ , and test-retest reliability was determined from a separate sample to be sufficient (intraclass correlation coefficient 0.77) (Norman, Schmid, Sallis, Calfas, & Patrick, 2005). They further dichotomized the sedentary time into less than 4 hours per day and more than 4 hours per day of sedentary time and found the validity for the dichotomized sedentary behavior index to have significant coefficients for percent body fat ( $r = 0.13$ ,  $p < 0.001$ ), aerobic fitness ( $r = -0.11$ ,  $p < 0.001$ ) and average daily minutes of vigorous physical activity measured with accelerometers ( $r = -0.17$ ,  $p < 0.001$ ). Studies that report children and parents estimates of sedentary behavior time with an adapted SBQ found parent-child agreement Spearman to be  $r = 0.16$ ,  $p < 0.05$ , and test-retest reliabilities high for each individual item, ranging from 0.79 to 0.93 (Robinson, 1999; Robinson & Killen, 1995). Finally, when the subjective SBQ measure was compared to an objective accelerometer, there was significant correlation with one another for average time spent sedentary on weekdays ( $r = 0.32$ ,  $p = 0.02$ ) and all days ( $r = 0.33$ ,  $p = 0.02$ ) (Bond et al., 2013). The intraclass correlation coefficient in Bond et al (2013) was found to be poor, but taken together, suggest that there is a large amount of random measurement error that tends to balance out across an entire sample but may make accurate estimate of any single participants sedentary behavior highly unreliable.

*Leisure-time sedentary behavior.* Sedentary behavior was assessed by estimating the time spent in a variety of sedentary behaviors outside of school time. The SBQ assessed the amount of time spent doing seven behaviors: watching television, playing computer/video



games, sitting and reading, sitting while listening to music, sitting and talking on the phone, sitting while hanging out with friends, and sitting and texting on the phone. These seven items were completed separately for weekdays and weekend days. Wording for weekday reporting was, “on a typical weekday, how much time do you spend (from when you wake up until you go to bed) doing the following?” For the weekend, wording was the same except “weekday” was replaced with “weekend day.” Responses were recorded as hours per day spent on the activity, with the time spent on each behavior less than an hour converted into hours (for example, a response of 15 minutes was coded as .25 hours).

For the total scores of sedentary behavior, hours per day for each item were summed separately for weekday and weekend days. For the purposes of this study, estimates of leisure-time sedentary behavior were obtained using weekend day hours reported and summed for an estimate of total leisure-time sedentary hours/week. Consistent with other studies, the sum of sedentary hours on non-school day responses was used as the outcome variable as non-school days are likely to include additional unstructured time for an adolescent, allowing for more time to engage in sedentary behaviors (Norman, Schmid, Sallis, Calfas, & Patrick, 2005; Owen, Leslie, Salmon, & Fotheringham, 2000). For the summed total leisure-time sedentary behaviors on the weekend days, responses higher than 24 hours per day were truncated to 24 hours per day. The outcome variable was average hours spent in leisure-time sedentary behaviors on typical weekend days.

*Screen-time:* Screen time was assessed by examining two specific sedentary behaviors that were collected on the SBQ, which included time spent watching television and time spent utilizing computer/video games. Responses were recorded as hours per day spent on the activity, and any responses higher than 24 hours per day were truncated to 24 hours per day. The

outcome variable was total average hours spent while utilizing the television, computer, and video games on a typical weekend day.

### **Data Analysis and Hypothesis Testing**

Data from the questionnaires were gathered and collected by the study coordinator for entering into the study database spreadsheet. The current study utilized the Statistical Package for Social Sciences (SPSS) version 20 (Chicago, IL) to examine the proposed research questions. Descriptive statistics were used to describe the mean and standard deviation, as well as the median and range, of responses to items regarding physical activity levels and sedentary behavior. A Kruskal-Wallis one-way analysis of variance by ranks test of independent sample t-tests was utilized to determine the differences between the three groups on both self-reported physical activity levels and sedentary behaviors. The Kruskal-Wallis statistical test is designed for non-parametric data and has been found to be appropriate for use with small or unequal sample sizes and with inabilities to make assumptions on the underlying distributions of the data (Castellan, 1988; Kruskal & Wallis, 1952). The parametric equivalent of the Kruskal-Wallis test is the one way analysis of variance (ANOVA). While ANOVA tests depend on the assumption that all populations under comparison are normally distributed, the Kruskal-Wallis test places no such restriction on the comparison. A Spearman rho, non-parametric, rank-order correlation was used to measure the relationship between reported and measured variables. It is the nonparametric version of the Pearson product-moment correlation, and measures the strength of association between two ranked variables (Howell, 2014).

Significance was determined based on an alpha level of 0.05. If the obtained value of the Kruskal-Wallis test was significant, then at least one of the groups were different from at

least one of the others, and the method of multiple comparisons was used to determine which differences were significant (Castellan, 1988). The multiple comparisons equation is as follows:

$$|\bar{R}_u - \bar{R}_v| \geq z_{\alpha/k(k-1)} \sqrt{\frac{N(N+1)}{12} \left( \frac{1}{n_u} + \frac{1}{n_v} \right)}$$

The methods for each research question are:

**Research Question One.** To determine if the current self-reported physical activity levels of adolescent ELBW, late preterm, and full-term controls were significantly different, a Kruskal-Wallis test was calculated utilizing the outcome variable of average past year total MET hours per week for all activities.

**Sub-question a).** To determine the relationship between the self-reported physical activity and measured treadmill peak oxygen consumption, a Spearman-rho correlation was computed comparing two variables of interest: the outcome variable of the average past year total MET hours per week for all activities and the peak relative oxygen consumption (expressed in ml/kg/min) obtained from the treadmill exercise test.

**Research Question Two.** To determine if the intensity levels of the preferred physical activities (labeled with their corresponding MET level values and categorized as light, moderate, or high intensity) were significantly different between the three groups, an ANOVA test was calculated utilizing the outcome variables of number of self-reported physical activities categorized as light, moderate, or high intensity as designated on the past year leisure-time physical activity question on the MAQ.

**Research Question Three.** To determine if the current self-reported sedentary behaviors of adolescent ELBW, late preterm, and full-term controls were significantly different, a Kruskal-

Wallis test was computed comparing the outcome variable of average hours spent in leisure-time sedentary behavior on typical weekend days between the three groups of adolescents.

**Sub-question a).** To determine if the self-reported screen time usage was significantly different between the three groups, a Kruskal-Wallis test was computed comparing the outcome variable of total average hours spent while utilizing the television, computer, and video games on typical weekend days between the three groups.

### **Data Reporting**

Results from this study regarding interpretations of maximal exercise testing and pulmonary function testing were reported to the primary care physicians and parents of the adolescents to promote better outcomes regarding physical activity promotion and reduction of sedentary behaviors in these populations. If there were concerns about reactive airway disease, with parent permission, a referral to the Pulmonology clinic or possibly the Allergy/Immunology clinic occurred.

## **Chapter IV**

### **Results**

#### **Purpose**

The purpose of this study was to determine whether or not the self-reported physical activity levels and preferences of physical activities of unimpaired ELBW and late preterm adolescents differed significantly from full-term control adolescents. Additionally, physical activity characteristics were further examined by comparing the self-reported physical activity levels with measured peak oxygen consumption. Self-reported leisure-time sedentary behavior characteristics and screen time usage (television, computer, and video games) were also examined.

#### **Sample Demographics**

The subjects included in this study were formerly evaluated in an original Children's Mercy Hospital multidisciplinary follow-up study to six years of age. The original study included 41 ELBW children, 42 late preterm children, and 26 full-term control children (N=109). While all subjects were contacted to participate in this study, some chose to not participate (21%) and others were lost to follow up (79%). The remaining subjects fitting the inclusion criteria were additionally evaluated for this current study, which included 17 ELBW (27.9%), 21 late preterm (34.4%), and 23 full-term control (37.7%) adolescents, resulting in a sample size of 61. An individual samples t-test revealed no statistically significant differences in the subjects examined in this study from the original cohort on birth weight or gestational age. A Chi-Square test revealed no statistically significant differences on neonatal complications as measured with the use of oxygen at 36 weeks and being discharged while on oxygen between the subjects in this

study and the original cohort (see Appendix D for data analyses). There was a statistically significantly difference observed in race on the full-term adolescents only (with 84.6% Caucasian subjects in the original cohort vs. 52.2% Caucasian subjects in this study).

This study consisted of 42.6% (n=26) male and 57.4% (n=35) female participants, with a mean age of 15.43 years (SD = 2.27 years). A set of ANOVAs with Tukey pairwise comparisons follow-up was performed to determine differences in age, height, and weight at testing, as well as gestational age and birth weight. As called for in the study design, and presented in detail in Table 2, each group was significantly different in gestational age and birth weight. The full-term group was significantly older than the ELBW and late preterm group ( $16.69 \pm 2.28$  years vs.  $14.77 \pm 2.25$  and  $14.56 \pm 1.65$  years, respectively). The full-term group was also significantly taller and heavier ( $166.13 \pm 11.19$  cm vs.  $155.62 \pm 11.76$  cm and  $65.24 \pm 16.38$  kg vs.  $51.47 \pm 11.36$  kg, respectively) than the ELBW group, but not the late preterm group ( $160.03 \pm 8.39$  cm and  $57.56 \pm 14.13$  kg, respectively). A Chi-Square test of pairwise comparisons for all groups revealed no statistically significant differences on gender, ethnicity, current asthma treatment, recent hospitalizations in the past two years, or exercise complications (chest pain, dizziness, or syncope with exercise) between the three groups. A complete description of sample demographics and detailed sample characteristics are presented in Tables 2 and 3.

**Table 2:** *Demographics (N=61)*

	ELBW (n=17)	Late Preterm (n=21)	Full-Term (n=23)	p value (Mean diff)	p value (Mean Diff)	p value (Mean Diff)
	Median (mean rank) Mean $\pm$ SD	Median (mean rank) Mean $\pm$ SD	Median (mean rank) Mean $\pm$ SD	ELBW vs. Late Preterm	ELBW vs. Full-Term	Late Preterm vs. Full-Term
Gestational Age (weeks)	24.00 (9.00) 24.76 $\pm$ 1.25	33.00 (28.00) 33.1 $\pm$ 1.67	40.00 (46.00) 39.4 $\pm$ 0.91	0.000* (-8.33)	0.000* (-14.64)	0.000* (-7.69)
Birth Weight (grams)	694.00 (9.00) 691.06 $\pm$ 67.36	1920.00 (28.00) 1953.24 $\pm$ 281.37	3465.00 (46.00) 3615.33 $\pm$ 621.29	0.000* (-1262.18)	0.000* (-2924.28)	0.000* (-1662.10)
Age at testing (years)	14.08 (25.09) 14.77 $\pm$ 2.25	14.17 (25.81) 14.56 $\pm$ 1.65	17.42 (40.11) 16.69 $\pm$ 2.28	0.950 (0.21)	0.015* (-1.92)	0.004* (-2.13)
Height at testing (cm)	157.50 (23.47) 155.62 $\pm$ 11.76	158.50 (28.33) 160.03 $\pm$ 8.39	166.25 (39.00) 166.13 $\pm$ 11.19	0.407 (-4.41)	0.007* (-10.51)	0.140 (-6.10)
Weight at testing (kg)	50.20 (22.50) 51.47 $\pm$ 11.36	54.80 (30.00) 57.56 $\pm$ 14.13	65.10 (38.20) 65.24 $\pm$ 16.81	0.410 (-6.09)	0.012* (-13.78)	0.195 (-7.68)

**Table 3:** *Subject characteristics (N=61)*

	ELBW (n=17)	Late Preterm (n=21)	Full-Term (n=23)	p value  (ELBW vs. Late Preterm)	p value  (ELBW vs. Full- Term)	p value  (Late Preterm vs. Full-Term)
<b>Gender</b>						
Male (%)	6 (35.3%)	10 (47.6%)	10 (43.5%)	0.736	0.868	0.960
Female (%)	11 (64.7%)	11 (52.4%)	13 (56.5%)			
<b>Ethnicity</b>						
White, non Hispanic (%)	12 (70.6%)	17 (81%)	12 (52.2%)	0.469	0.930	0.229
Black, non Hispanic (%)	4 (23.5%)	4 (19%)	11 (47.8%)			
Hispanic or Latino/a (%)	1 (5.9%)	0 (0%)	0 (0%)			
<b>Current Asthma Treatment</b>						
Yes (%)	4 (23.5%)	3 (14.3%)	4 (17.4%)	0.752	0.877	0.963
No (%)	13 (76.5%)	18 (85.7%)	19 (82.6%)			
<b>Recent Hospitalizations</b>						
Yes (%)	3 (17.6%)	0 (0%)	3 (13%)	0.170	0.878	0.317
No (%)	14 (82.4%)	21 (100%)	20 (87%)			
<b>Chest Pain with exercise</b>						
Yes (%)	5 (29.4%)	4 (19%)	5 (21.7%)	0.741	0.842	0.976
No (%)	12 (70.6%)	17 (81%)	18 (78.3%)			
<b>Dizziness with exercise</b>						
Yes (%)	4 (23.5%)	9 (42.9%)	7 (30.4%)	0.430	0.892	0.663
No (%)	13 (76.5%)	12 (57.1%)	16 (69.6%)			
<b>Syncope with exercise</b>						
Yes (%)	3 (17.6%)	2 (9.5%)	1 (4.3%)	0.687	0.356	0.836
No (%)	14 (82.4%)	19 (90.5%)	22 (95.7%)			

\*p&lt;0.05



Physical activity levels, leisure-time sedentary behaviors and screen time characteristics were also analyzed. Self-reported physical activity levels and maximal oxygen consumption are presented in Table 4. The data on weekend total leisure-time sedentary behavior and screen time usage are presented in Table 5.

**Table 4:** *Physical activity characteristics and maximal oxygen consumption*

	ELBW (n=17) Median (mean rank) Mean $\pm$ SD	Late Preterm (n=21) Median (mean rank) Mean $\pm$ SD	Full-Term (n=23) Median (mean rank) Mean $\pm$ SD	X <sup>2</sup> (p value) between groups
Self-reported past year MET hours per week of physical activity	33.15 (26.41) 49.23 $\pm$ 49.63	45.03 (30.90) 53.71 $\pm$ 35.95	48.53 (34.48) 68.46 $\pm$ 60.40	2.019 (0.364)
Measured maximal oxygen consumption (ml/kg/min)	37.80 (28.21) 38.75 $\pm$ 9.88	44.50 (34.10) 42.96 $\pm$ 10.47	39.60 (30.24) 40.55 $\pm$ 10.40	1.102 (0.576)

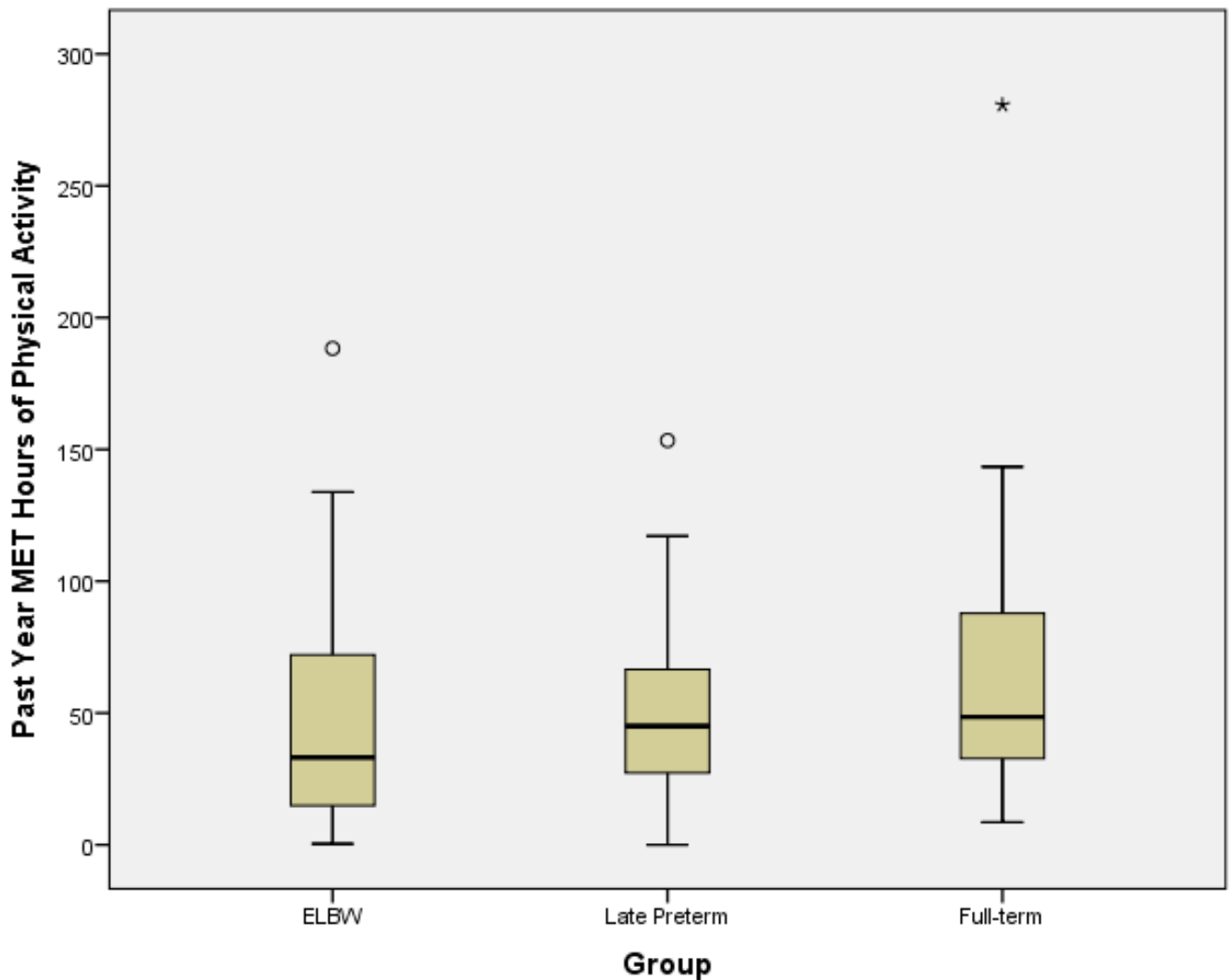
**Table 5:** *Weekend total sedentary behavior time and screen time*

	ELBW (n=17) Median (mean rank) Mean $\pm$ SD	Late Preterm (n=21) Median (mean rank) Mean $\pm$ SD	Full-Term (n=23) Median (mean rank) Mean $\pm$ SD	X <sup>2</sup> (p value) between groups
Sedentary behavior time on weekend (hours)	10.00 (23.47) 10.86 $\pm$ 7.11	12.00 (32.76) 14.42 $\pm$ 6.92	15.17 (34.96) 15.07 $\pm$ 5.72	4.434 (0.109)
Screen time: television/movies, computer, video games (hours)	2.00 (22.74) 3.49 $\pm$ 3.73	4.00 (32.90) 5.19 $\pm$ 4.43	4.50 (35.37) 5.72 $\pm$ 4.37	5.337 (0.069)

### Research Question One

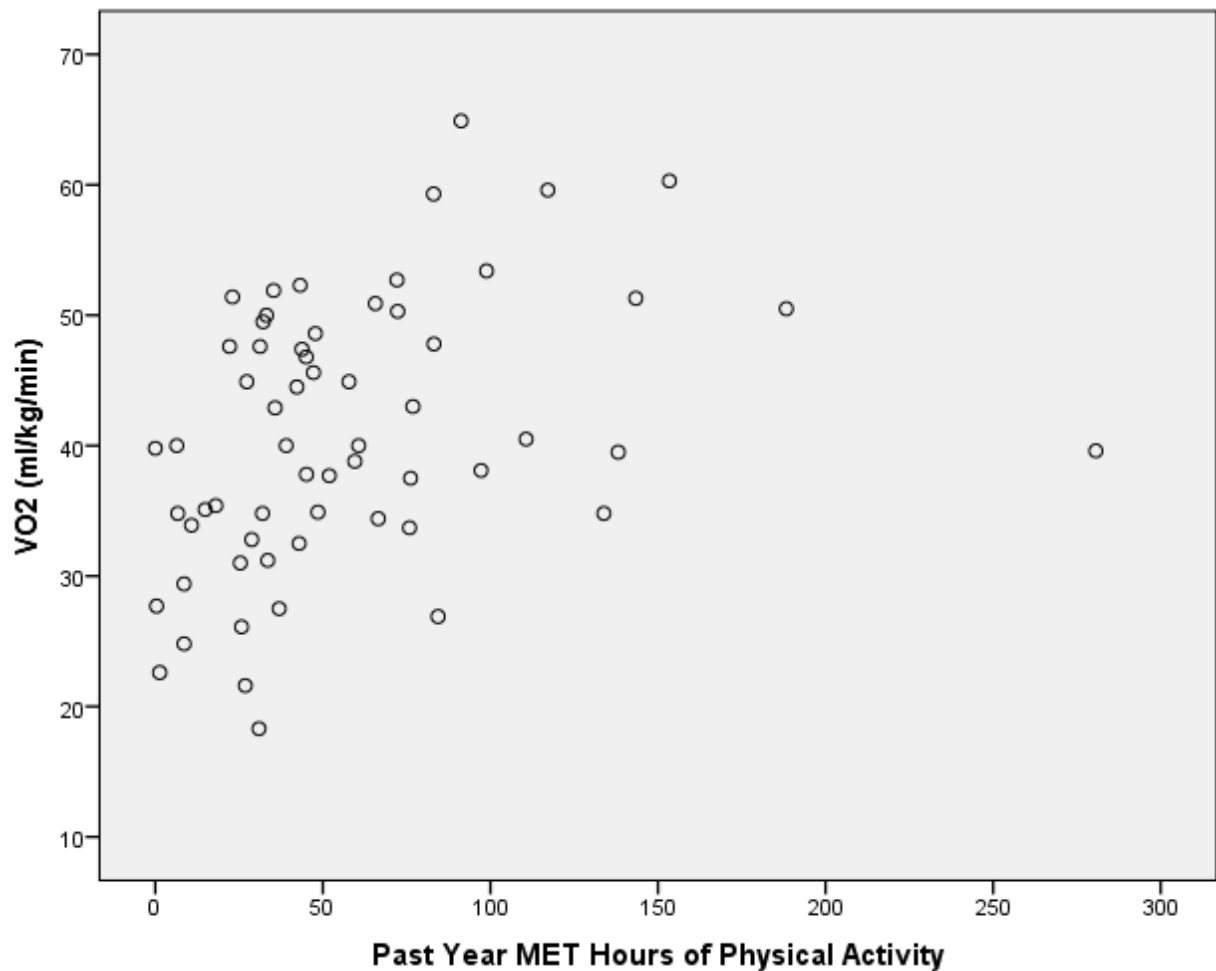
This study was designed to determine whether or not the current self-reported physical activity levels of adolescent ELBW, late preterm, and full-term controls were significantly different. A Kruskal-Wallis test was used to calculate if the outcome variable of average past year total MET hours per week for all activities were different across groups. There were no statistically significant differences in self-reported physical activity levels between groups ( $X^2 = 2.019$ ,  $df = 2$ ,  $p = 0.364$ ). The results of this test are presented in Figure 1.

**Figure 1:** *Self-reported MET hours per week by group*



**Sub-question a).** The relationship between the self-reported physical activity and measured treadmill peak oxygen consumption was evaluated. A Spearman-rho correlation was computed that compared two variables of interest: the outcome variable of the average past year total MET hours per week for all activities and the maximal relative oxygen consumption (expressed in ml/kg/min) obtained from the treadmill exercise test. A significant positive correlation was found between self-reported MET hours per week and maximal relative oxygen consumption ( $r_s = 0.450$ ,  $df = 61$ ,  $p = 0.000$ ).

**Figure 2:** *Maximal oxygen consumption and self-reported past year MET hours of physical activity*



### Research Question Two

To determine if the intensity levels of the preferred physical activities (labeled with their corresponding MET level values and categorized as light, moderate, or high intensity) were significantly different between the three groups, an ANOVA test was calculated utilizing the outcome variables of number of self-reported physical activities categorized as light, moderate, or high intensity as designated on the past year leisure-time physical activity question on the MAQ. There were no statistically significant differences in number of physical activities in the 3 intensity levels between groups (light intensity physical activity:  $F(2,57) = 1.522$ ,  $p = 0.227$ , moderate intensity physical activity:  $F(2,57) = 0.427$ ,  $p = 0.654$ , high intensity physical activity:  $F(2,57) = 1.315$ ,  $p = 0.276$ ). The data on average number of light, moderate, and hard intensity physical activities reported by group are presented in Table 6.

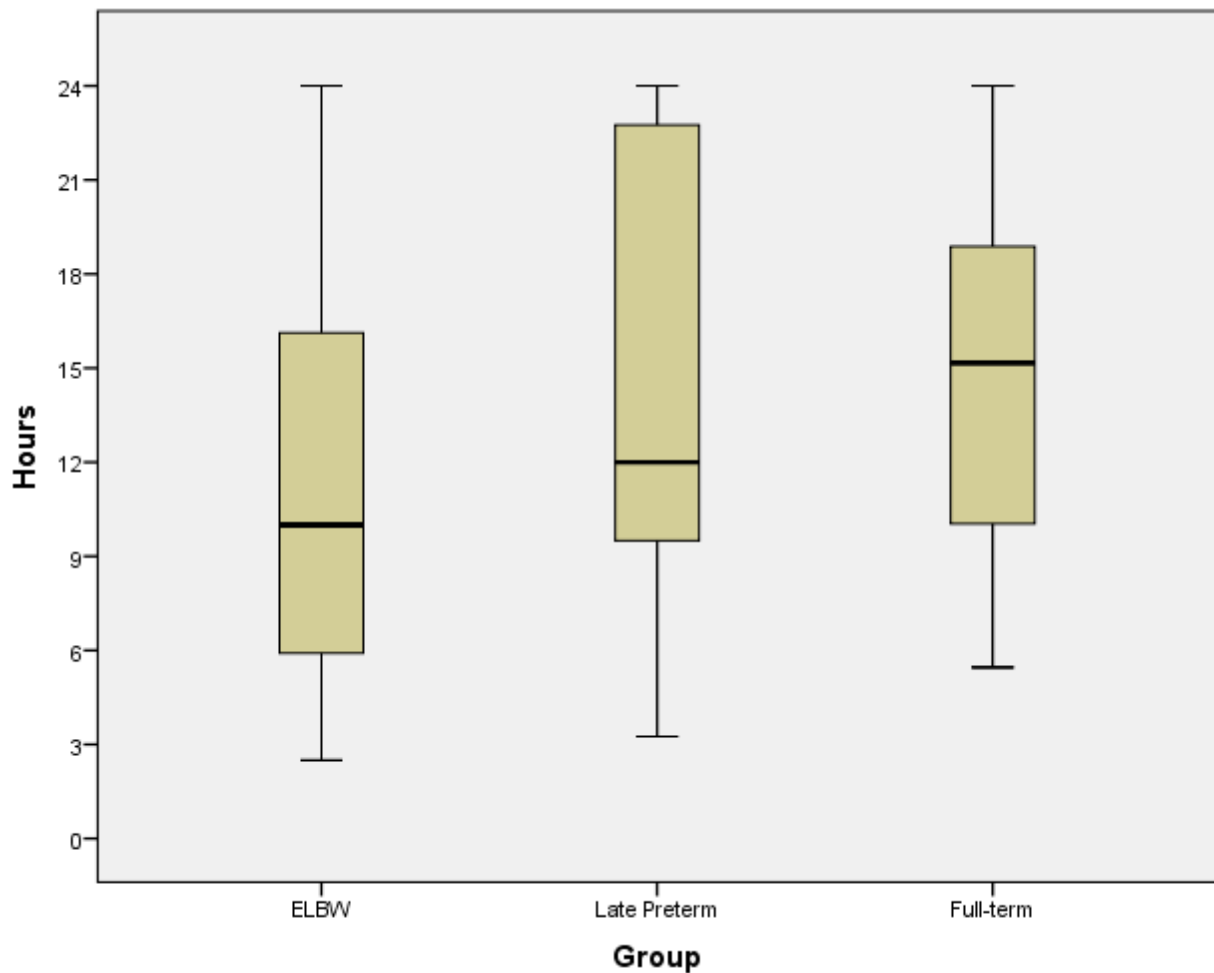
**Table 6:** *Average number of physical activities reported with light, moderate, and hard intensities (N=61)*

	ELBW (n=17) mean $\pm$ SD	Late Preterm (n=21) mean $\pm$ SD	Full-Term (n=23) mean $\pm$ SD	F value (p value)
Light intensity (1.6 -3.0 METS)	0.47 $\pm$ 0.72	0.57 $\pm$ 0.81	0.87 $\pm$ 0.76	1.522 (0.227)
Moderate intensity (3.1- 6.0 METS)	3.35 $\pm$ 2.26	3.90 $\pm$ 2.21	3.39 $\pm$ 1.95	0.427 (0.654)
Hard intensity (> 6.1 METS)	1.41 $\pm$ 1.46	1.48 $\pm$ 1.25	2.00 $\pm$ 1.21	1.315 (0.276)

### Research Question Three

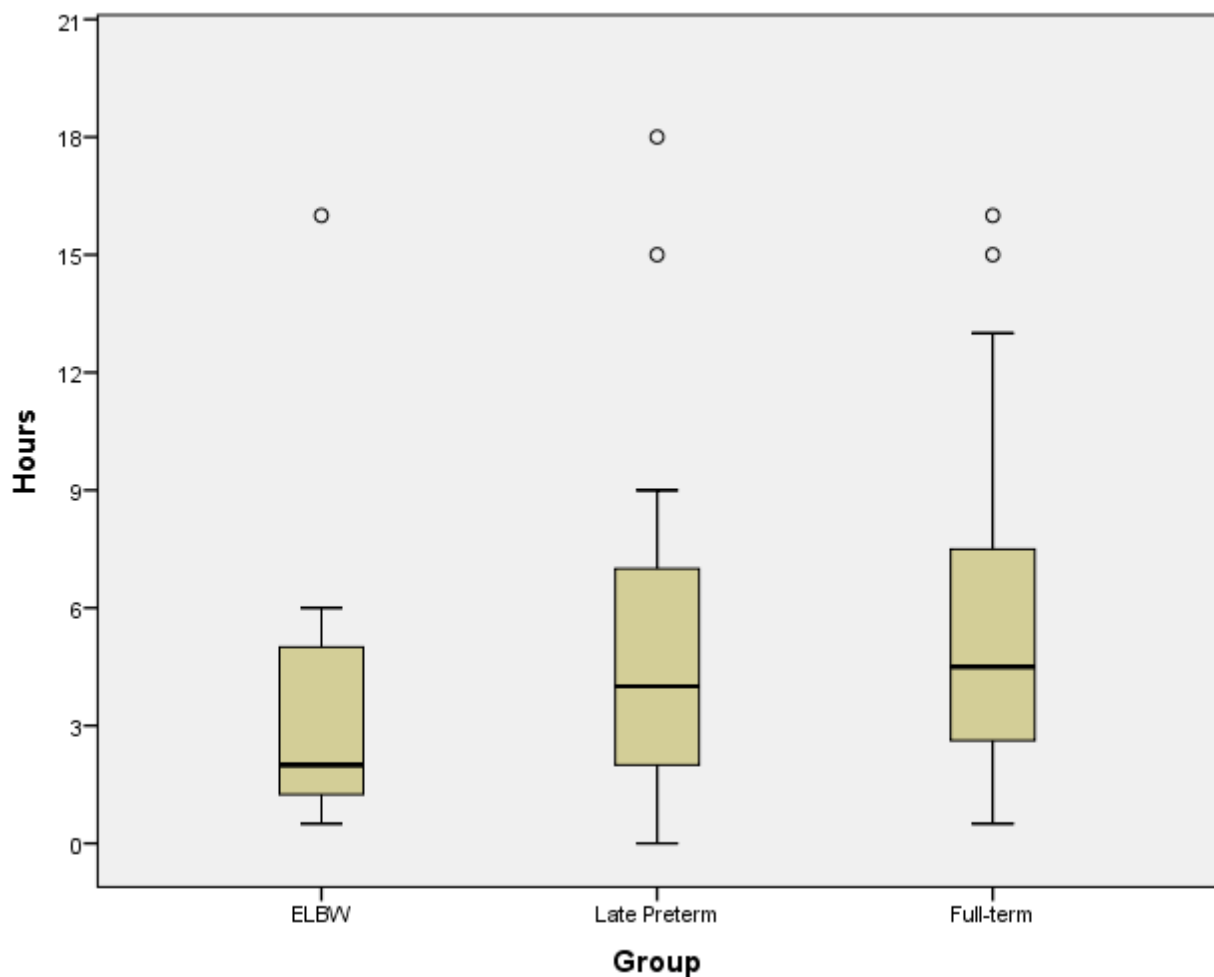
To determine whether or not current self-reported sedentary behaviors of adolescent ELBW, late preterm, and full-term controls were significantly different, a Kruskal-Wallis test was computed comparing the outcome variable of average hours spent in leisure-time sedentary behavior on typical weekend days between the three groups of adolescents. There were no significant differences in weekend sedentary behaviors between groups ( $X^2 = 4.434$ ,  $df = 2$ ,  $p = 0.109$ ). The results of this analysis are displayed in Figure 3.

**Figure 3:** *Self-reported weekend sedentary behaviors by group*



**Sub-question a).** To determine differences in self-reported screen time usage between the three groups, a Kruskal-Wallis test was computed comparing the outcome variable of total average hours spent while utilizing the television, computer, and video games on typical weekend days between the three groups. There were no significant differences in self-reported weekend screen time usage between groups ( $X^2 = 5.337$ ,  $df = 2$ ,  $p = 0.069$ ). The information presented in Figure 4 describes self-reported screen time usage by groups.

**Figure 4:** *Self-reported screen time usage by groups*



## **Chapter V**

### **Discussion**

#### **Purpose**

The purpose of this study was to determine whether or not the self-reported physical activity levels and preferences of physical activities of unimpaired ELBW and late preterm adolescents differed significantly from full-term control adolescents. Additionally, physical activity characteristics were further examined by comparing the self-reported physical activity levels with measured peak oxygen consumption. Self-reported leisure-time sedentary behavior characteristics and screen time usage (television, computer, and video games) were also examined.

#### **Research Question One**

The current self-reported physical activity levels of adolescents were found to be not significantly different across birth weights. These results suggest that adolescents born both ELBW and late preterm report similar physical activity levels as their term-born control peers. This finding from this study is in agreement with other studies that have examined physical activity levels in low birth weight children. Although Hallal et al (2006) had their lowest birth weight group at <2500 grams, similar to the late preterm group in this study, they found no significant difference in low birth weight and normal birth weight children with reported minutes of physical activity. The lower birth weight group reported slightly fewer minutes of weekly activity ( $p>0.05$ ) at ages 10-12 than their peers of higher birth weight (Hallal, Wells, Reichert, Anselmi, & Victora, 2006). However, the low birth weight young adolescents in the study were much heavier than the ELBW adolescents assessed in this study.

Our findings are not consistent with other studies that have found significantly lower physical activity levels for ELBW and late preterm individuals. Rogers et al (2005) found that ELBW teenagers reported less frequent participation in physical activity, as well as sports, than control subjects (Rogers, Fay, Whitfield, Tomlinson, & Grunau, 2005). It was suggested that the lower participation in physical activity and sports may reflect the lower physically active lifestyle that the ELBW teens tend to choose. Anderson et al (2009) examined both low and high birth weights outside the normal range of birth weights and found they were associated with a lower probability of being physically active during leisure time. They concluded that the lower physical activity levels may be part of the underlying mechanism of the association between birth weight and disease and may have public health implications. This is especially important for those born with lower birth weights as they have been shown to have a higher risk of developing type 2 diabetes, metabolic syndrome, and coronary heart disease later in life (Andersen et al., 2009).

While our data were not statistically significant, they revealed an interesting trend that demonstrated increasing past year MET hours per week of physical activity with increasing birth weight categories (49.23 vs. 53.71 vs. 68.46, respectively), with ELBW and late preterm groups reporting lower MET hours per week than term-born controls. There are several physiologic reasons that may explain the lower, but not significantly different, levels of physical activity reported by the ELBW and late preterm groups. Some of the most common reasons found in recent low birth weight research are problems with early motor development and poorer motor coordination. Other possible explanations found are the association with a reduced physical capacity through a variety of mechanisms, including reduced muscle strength because of low muscle mass, insufficient anaerobic capacity, respiratory capacity, or aerobic fitness. These



factors could reduce the willingness of the adolescent to undertake physical activity because of early tiredness and reduced ability to perform physical activity (Andersen et al., 2009).

The data from this study suggest that even though the ELBW and late preterm report lower past year MET hours per week, they are still achieving the recommended level of moderate activity physical activity. For example, walking at a moderate pace on a level surface is equivalent to 3.5 METS, and doing this activity daily for 60 minutes would equal 24.5 METS hours per week. The ELBW and late preterm adolescents reported an average of 49.23 and 53.71 past year MET hours per week, respectively. By these results, all three groups are meeting the recommendations of children and adolescents ages 6-17 years to achieve 60 minutes or more of moderate-intensity physical activity each day.

Some of the subjects in this study were over 17 years old, and the ACSM recommends over 17 year old adults to accumulate 150 minutes per week of moderate-intensity physical activity (Garber et al., 2011), which the older subjects appear to be achieving, as well. 33% of the subjects in this study were over 17 years old, with 90% of them meeting the current ACSM recommendations. Those that did not meet the recommendations belonged to the ELBW group, who are already at a much higher risk for many metabolic disorders. Additionally, studies have reported that physical activity diminishes with age in normal adolescents (Saris, Elvers, Van't Hof, & Binkhorst, 1986; Verschuur & Kemper, 1985), and while this hasn't been addressed specifically in the ELBW and late preterm populations, it would indicate an even greater importance to encourage the preterm populations to achieve recommended physical activity levels as they emerge into adulthood.

**Sub-question a).** There was a significant positive correlation found when examining the relationship between the average past year total MET hours per week for all activities and the peak relative oxygen consumption. Similar to previous research (Aaron et al., 1993; Aaron et al., 1995; Andreacci et al., 2004; Kriska, Hanley, Harris, & Zinman, 2001), this relationship was utilized to provide an indirect assessment of validity of the questionnaire. The significant correlation of activity levels and fitness is consistent with research. Research has reported that aerobic fitness may be influenced by the level of physical activity, and that both physical activity and inactivity have been shown to have a significant effect on aerobic fitness in children (Rowlands, Eston, & Ingledew, 1999). Participation in higher intensity levels of physical activity should elicit more of the cardiovascular training response, thus increasing aerobic fitness as measured by peak relative oxygen consumption. Recent and continued participation in physical activity, as measured by past-year MET hours per week, is an important determinant of current measurable fitness. Moreover, individuals are more likely to recall higher intensity exercise, for instance, those activities that have higher MET levels associated with them (Aaron et al., 1995), allowing for the self-reported physical activity questionnaires, such as the MAQ, to provide a reasonable estimate of the habitual physical activity levels of adolescents.

In other studies, past-year leisure time physical activity, as measured by the MAQ, was shown to be significantly related to the past-week activity measured by an activity monitor (Kriska et al., 1990), and also have been shown to be significantly related when compared to assessment by other methods (Schulz, Harper, Smith, Kriska, & Ravussin, 1994). In this study, the relationship for hours per week of self-reported physical activity was significantly and positively related ( $r = 0.434$ ,  $p = 0.000$ ) to maximal relative oxygen uptake. The finding from this study is in agreement with another study that found hours per week of leisure activity was

related to other measures of activity assessed in the MAQ, specifically days of “hard exercise” and competitive athletic participation (Aaron et al., 1993). This would further indicate that the past-year leisure time physical activity estimation assesses habitual physical activity well.

Other studies have investigated differences in exercise capacities of preterm and term-born subjects (Clemm et al., 2012; Vrijlandt, Gerritsen, Boezen, Grevink, & Duiverman, 2006). Clemm et al (2012) found differences in aerobic capacity between preterm and term-born cohorts to be minor and not statistically significant. They found no significant decreases for average peak  $\text{VO}_2$  or anaerobic threshold. This author concluded that leisure-time physical activity, as measured by questionnaire, was similarly and positively associated with exercise capacity in preterm and term-born adolescents alike, although participation was lower among those born preterm (Clemm et al., 2012). This study found no statistically significant differences in the maximal oxygen consumption between birth weight groups, as the groups appear to be participating in similar frequencies and intensities of physical activities. Consequently, the groups would likely obtain similar levels of aerobic fitness, as measured by the maximal treadmill test.

## **Research Question Two**

Preferences of physical activities (categorized as light, moderate, or high intensity) that were indicated on the MAQ were not significantly different ( $p>0.05$ ) between the three groups. This was found by examining the variety of over 40 physical activities that were indicated by the adolescents on the MAQ questionnaire. The examination of light, moderate, and high intensity levels of physical activity preferences in the preterm population has not been well studied.

There have been a few recent studies examining Finnish VLBW adolescents that conclude unimpaired young VLBW adults are less physically active during leisure time than their peers born at term (Hovi et al., 2007; Kajantie et al., 2010). This difference was characterized by a lower frequency, intensity, and average session duration of leisure-time physical activity. While the findings from this study do not agree with these studies (Hovi et al., 2007; Kajantie et al., 2010), one possible mechanism may be how intensity level was assessed. In the study conducted by Kajantie et al (2010), participants were asked to evaluate their leisure-time exercise as being comparable to one of four categories: walking, intermittent walking/ light running, jogging, or brisk running. Similarly, in the Hovi et al (2007) study, participants were to categorize their regular leisure-time exercise activity as walking, walking/light running, light running, brisk running, or unknown. The actual physical activities participated in were not assessed, relying only on the comparison of the activity to one of five categories. This study specifically compared the MET levels of over 40 different self-reported physical activities, rather than categorizing the physical activities as ‘most like’ one of a few choices. Results of these studies are difficult to compare as the methodologies were different, however, the method used in this study allows for a more precise estimation of the intensity levels of the preferred physical activities participated in by the adolescents.

There appears to be some disagreement in the research concerning preference of physical activity intensity levels. Salonen et al (2010) found that children who were heavier and taller at ages 2, 7, and 11 years reported higher intensity levels of conditioning leisure time physical activity as adults. Conversely, other studies have found that both low and high birth weights were associated with lower intensity leisure time physical activity (Andersen et al., 2009; Davies, Smith, May, & Ben-Shlomo, 2006). The relationship between birth weight and preference of

leisure-time physical activity appears to be complex, and the measurement of physical activity has been variable in past research, which may possibly explain some of the contradictory findings. This study revealed similar intensity levels of preferred physical activities. The area surrounding this topic continues to need further research, and as such, there are few conclusions that can be made.

### **Research Question Three**

Literature provides contradictory information on the issue of sedentary behavior in the preterm population. This study found no statistically significant differences ( $p>0.05$ ) on the average hours spent in leisure-time sedentary behavior on typical weekend days between the three groups of adolescents. The finding from this study is in agreement with another study (Ridgway et al., 2008) which examined associations between birth weight and sedentary time. They also found no evidence for any gender interaction within any studies, which previous research has noted to be different in the normal adolescent population (Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006). Ridgway et al (2008) concluded that their combined analysis did not find evidence that low birth weight (<1500 grams) predicts objectively measured habitual physical activity and sedentary time in healthy young people.

Other studies have found significant associations between birth weight and sedentary time. The data from the Roots study (Goodyer, Croudace, Dunn, Herbert, & Jones, 2010) suggested an inverse relationship with an association between higher birth weight and lower sedentary time, appearing to be largely driven by those in the lower quintiles of birth weight. In contrast, the Pelotas study (Hallal, Wells, Reichert, Anselmi, & Victora, 2006) suggested that higher birth weight was associated with reduced total physical activity and increased sedentary

time. These findings were in opposition to the hypothesized association, which was lower self-reported leisure time activity in those with very low birth weight (Hallal et al., 2006). Moreover, the Pelotas study found that the majority of children with sedentary lifestyles belonged to the lowest birth weight group, but the association between birth weight and lifestyle was not statistically significant ( $p>0.05$ ). They concluded that genetic factors or habit formation during early childhood seemed to be of greater importance in determining lifestyle than physiological factors (Hallal et al., 2006). These studies did discuss limitations such as influence of gestational age, and they attempted to minimize the influence of premature infants by excluding those born with very low birth weight, unlike this study. Poor early coordination combined with low self-confidence may contribute to lack of establishment of healthy levels of physical activity in childhood as well as lack of common knowledge of and skills for group sports and activities. This carries into young adulthood, contributing to poor self-image and lack of association with more socially and physically active peers. These factors may add to the overall tendency of ELBW teens to be more sedentary compared with their peers.

The trend of increasing sedentary behavior with increasing birth weight that was observed in this study may be related to the age difference in the adolescents. The ELBW group (mean age of 14.77 years) had the lowest self-reported weekend leisure-time sedentary behavior (10.86 hours) and the full-term group (mean age of 16.69 years) had the highest self-reported weekend leisure-time sedentary behavior (15.07 hours). Though not significantly different ( $p>0.05$ ), this finding may be explained by previous studies reporting older adolescents engaged in more sedentary time than younger adolescents. As adolescents move into their teenage years, they likely increase the time spent engaging in multiple sedentary behaviors that compete with physical activities (Norman, Schmid, Sallis, Calfas, & Patrick, 2005; Hardy et al., 2007; Norman

et al., 2005; Sisson et al., 2009). Older adolescents have more time that is not supervised by a parent or caregiver, which creates opportunities to increase TV-viewing time and other sedentary behaviors. Encouraging alternative physical activities or teaching ways to engage in physical activity while engaging in pastimes such as listening to music, talking on the phone, and watching TV may help older adolescents to develop less sedentary lifestyles.

Previous work has suggested that ELBW and late preterm adolescents lead a more sedentary lifestyle because these groups generally report less physically active lifestyles. Based on recent studies, this conclusion may not be accurate and often, subjects have been categorized as sedentary by default, not on the basis of measured participation in sedentary behavior (Pate, O'Neill, & Lobelo, 2008). Rosenberg et al (2010) and Norman et al (2005) measured both activity levels and sedentary behaviors, and found that the sedentary behavior scores were unrelated to physical activity. They suggested that the sedentary behavior questionnaires are able to measure a distinct class of low energy expenditure behaviors, further suggesting that being sedentary should not be inferred from low levels of moderate to vigorous physical activity. Furthermore, available evidence indicates that sedentary behaviors are not the mirror image of physical activity and that these behaviors are relatively uncorrelated.

Studies focused on physical activity levels of preterm children have often drawn conclusions about the sedentary behaviors of these adolescents while not actually measuring sedentary behavior. Assumptions were made that the ELBW and preterm adolescents were more sedentary simply from reporting less physically active lifestyles. However, recent research cautions the use of this approach, suggesting that any conclusions regarding the influence of sedentary behavior should be drawn only if sedentary behavior was measured and used analytically (Pate et al., 2008). Therefore, studies making conclusions regarding ELBW and

preterm adolescents' sedentary behaviors may be inaccurate if sedentary behavior was not specifically examined. If specific surrogate behaviors are used to study sedentary activity (such as television watching), or physical activity (such as walking), conclusions should be stated in terms that are limited to those behaviors (Pate et al., 2008).

**Sub-question a).** Screen time usage (television, computer, and video games) on typical weekend days were found to not be significantly different between the three groups. This study appears to be the first study done that has specifically examined screen time usage in ELBW and late preterm adolescents. While this study revealed non-significant results regarding screen time usage, there was an interesting trend observed noting increased screen time usage with increasing birth weight groups. As with sedentary behavior, research has noted that older adolescents tend to engage in more screen time usage (Hardy et al., 2007; Norman et al., 2005; Sisson et al., 2009) than younger adolescents. It is intriguing to note that this increasing trend may be accurate in the preterm population as well.

Screen time usage is particularly important to assess while engaging in sedentary behavior as it has been shown to contribute to obesity and other undesirable health outcomes, such as reduced energy expenditure from displacement of physical activity and increased dietary energy intake, either during viewing or as a result of food advertising (Robinson, 1999). As the preterm population continues to be at increased risk for multiple metabolic issues, the assessment of screen time should become a research topic of great importance for health interventions.

The amount of screen time reported by the three groups in this study is much higher than the recommended time to be spent utilizing televisions, computers and video games. Studies have shown, including when they're multitasking, that 8- to 18-year-olds consume an average of



7 hours of screen time per day, which, based on previous research, has increased more than 2.5 hours in just 10 years (Rideout, Foehr, & Roberts, 2010). While the adolescents from this study did report less screen time than the average indicated by Rideout et al (2010), the groups do average almost 3 more hours of self-reported daily weekend screen time than is recommended for older children and adolescents by the American Academy of Pediatrics (Strasburger, 2010).

Interestingly, even while the amounts of screen time do appear to be excessive in the three groups from this study, these adolescents were able to achieve adequate amounts of physical activity. This is similar to findings by Biddle et al (2004), which showed the cluster of adolescents with the highest TV viewing and telephone use for girls were also reasonably active. Biddle et al (2004) concluded that certain sedentary behaviors, such as TV viewing, were not necessarily obstacles to physical activity, contrary to popular belief. While screen time is inevitably prohibitive of physical activity during the time of use, one should not assume that screen time behavior is inversely correlated with physical activity over the whole day, week, or month (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004). Associations between physical activity and screen time were studied by Melkevik et al (2010). They found that there were stronger negative associations between physical activity and screen time behaviors in countries where the level of physical activity is relatively high. This indicated that physical inactivity is not a consequence of adolescents spending too much time in screen time behaviors, but rather that inactive adolescents have more time to spend in different sedentary pursuits. The stronger negative association between physical activity and TV for girls versus gaming for boys may thus simply reflect that inactive girls tend to watch more TV while inactive boys tend to spend more time playing computer games (Melkevik, Torsheim, Iannotti, & Wold, 2010).

For older children and adolescents, excessive screen time is linked to increased psychological difficulties that include hyperactivity, emotional and conduct problems, difficulties with peers and poor school performance (Johnson, Cohen, Kasen, & Brook, 2007; Page, Cooper, Griew, & Jago, 2010). Adolescents who watch three or more hours of television daily are at especially high risk for poor homework completion, negative attitudes toward school, poor grades, and long-term academic failure (Johnson et al., 2007). This is important to consider for the ELBW and late preterm adolescents that have already been shown to be at an increased risk for poor school performance and behavioral issues (de Jong et al., 2012; Farooqi, Hagglof, Sedin, Gothefors, & Serenius, 2007).

The reduction of screen time in adolescents may be helpful in preventing childhood obesity. With the rapid development of information technologies for communication and entertainment, the emergence of ‘information environments’ as a sedentary behavior setting is of increasing relevance. Screen time usage may have an important role to play in the assessment of physical activity behaviors and obesity prevention and management, but data suggest that we should not lose sight of the bigger picture by focusing only on a narrow range of sedentary behaviors or possible explanations.

## **Chapter VI**

### **Summary, Conclusions, and Recommendations**

#### **Summary**

As survival rates of ELBW and late preterm infants have improved dramatically, and with preterm birth rates estimated to be approximately 9.6% worldwide (Beck et al., 2010), the first infants who experienced modern neonatal intensive care are now young adults. Although most of them experience good health (Saigal & Doyle, 2008), some studies show increased premorbid risk factors of chronic adult disease, such as type 2 diabetes, hypertension, metabolic syndrome, and coronary heart disease later in life (Andersen et al., 2009). These risk factors raise substantial concern for health professionals, the ELBW and late preterm individuals themselves, and society as a whole.

Establishing early, adequate levels of fitness and activity may be particularly important in former tiny infants, who may be at risk for early-onset adult diseases. Regular physical activity has been shown to be effective in the secondary prevention of cardiovascular disease and is effective in attenuating the risk of premature death among men and women. It can improve aerobic and musculoskeletal fitness, which has increasing evidence to be associated with an improvement in overall health status and a reduction in the risk of chronic disease and disability (Warburton, Gledhill, & Quinney, 2001). Participation in regular physical activity is a contributor to good overall health, whereas inactivity and poor physical fitness are recognized as significant health risks. Lack of physical activity may be a significant contributor to the increasing rate of childhood obesity and metabolic syndrome.

While there are limited studies that assess physical activity in the ELBW and late preterm adolescent population, the majority of these studies utilize short-term collection of physical activity information. This study was able to assess more habitual physical activity by evaluating past-year leisure-time physical activity, which obtained the most accurate picture of the individual's usual activity level. Physical activity levels in the ELBW and late preterm population may be generally addressed by the physicians in care of the adolescents, but specifics regarding habitual physical activity and preferences of physical activity that may help with promotion of appropriate healthy behaviors remain unclear.

Researchers have identified unique health consequences of 'too much sitting' that are different from those of 'too little exercise'. Thus far, studies that assessed sedentary behavior in preterm adolescents have drawn conclusions based on lack of physical activity. This study specifically examined self-report weekend sedentary behaviors and screen time in the ELBW and late preterm adolescent population, which allowed for assessing how little or how much physical inactivity adolescents and young adults are engaged in and addressing what they are actually doing while they are sedentary. Efforts to better understand the sedentary behavior patterns of these adolescents fulfill an important void in the research and may help improve health outcomes for this unique population.

This study was designed to evaluate the current physical activity levels and sedentary behaviors of ELBW and late preterm adolescents and identify possible areas of focus for promotion of healthy lifestyle habits. Specifically, it included assessing past-year MET hours per week of physical activity and identifying preferences in intensity levels of physical activity. Additionally, the relationship between the maximal oxygen consumption and physical activity

levels was determined. Sedentary behavior was evaluated and further assessed by specifically examining screen time in the form of television viewing, and computer and video game usage.

This study was carried out utilizing descriptive statistics (ANOVA and independent samples t-tests) and non-parametric analyses consisting of Kruskal-Wallis tests and a Spearman-rho correlation. This process included examining the ELBW, late preterm and full-term adolescents' physical activity levels and characteristics, while also examining time spent in sedentary behavior and utilization of screen time on the weekends. The results obtained from this study lead to the following conclusions and recommendations.

### **Conclusions**

Based upon the results of this study, four conclusions were made:

1. Although the full-term group reported the most MET hours per week, these unimpaired ELBW and late preterm adolescents did not appear to be notably impacted by their prematurity in a way that manifested in significantly decreased participation in physical activities.
2. The MAQ appeared to allow for appropriate estimation of regular physical activity in these premature adolescents that was further supported by formal exercise testing.
3. All three groups of adolescents were found to be making the healthiest choice of physical activity by frequently selecting physical activity at a moderate intensity level.
4. This group of unimpaired ELBW and late preterm adolescents do not favor sedentary activities more than full-term control adolescents; however, they should be educated on healthy lifestyle habits and strategies to help reduce time spent in sedentary pursuits.

## **Recommendations**

Based upon the findings from this study, the following recommendations for future studies were made:

1. Repeat the study with increased sample sizes in each group to help increase the power of the study, with a smaller age range of subjects in an attempt to minimize the effects of age on physical activity preferences and engagement in leisure-time sedentary behaviors.
2. Continue the study using data collected on the physical activity levels and sedentary behaviors of ELBW and late preterm adolescents as they age into young adulthood and test its association with adult health outcomes.
3. Replicate the study using questionnaire data collected on more impaired ELBW and late preterm adolescents to assess the impact of extreme prematurity on physical activity levels and preferences of physical activities.
4. Further examine actual measured sedentary behavior time, possibly through use of accelerometers, in the ELBW and late preterm populations and test its association with health outcomes. Most of the research done makes conclusions about sedentary behaviors while only assessing physical activity behaviors; sedentary behaviors are a class of behaviors that can coexist with and also compete with physical activity.
5. Further examine how the topic of physical activity and its promotion is addressed between the medical providers and the ELBW and late preterm patient and family members/caretakers. Incorporation of information regarding the safety and importance of regular physical activity is necessary in the follow-up of children born ELBW and late preterm and should be encouraged.

6. Further examine physical activity levels and sedentary behaviors of ELBW and late preterm children across a continuum of ages to identify opportune times for intense education and interventions with emphasis on healthy lifestyles and behaviors.

## References

- Aaron, D. J., Kriska, A. M., Dearwater, S. R., Anderson, R. L., Olsen, T. L., Cauley, J. A., & LaPorte, R. E. (1993). The epidemiology of leisure physical activity in an adolescent population. *Medicine and Science in Sports and Exercise*, 25(7), 847-853.
- Aaron, Deborah J, Kriska, Andrea M, Dearwater, Stephen R, Cauley, Jane A, Metz, Kenneth F, & LaPorte, Ronald E. (1995). Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *American Journal of Epidemiology*, 142(2), 191-201.
- Adamopoulos, S., Parissis, J., Kroupis, C., Georgiadis, M., Karatzas, D., Karavolias, G., . . . Kremastinos, D.Th. (2001). Physical training reduces peripheral markers of inflammation in patients with chronic heart failure. *European Heart Journal*, 22(9), 791-797.
- Agresti, Alan. (2014). *Categorical data analysis*: John Wiley & Sons.
- Ainsworth, Barbara E, Haskell, William L, Whitt, Melicia C, Irwin, Melinda L, Swartz, Ann M, Strath, Scott J, . . . Emplaincourt, Patricia O. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and science in sports and exercise*, 32(9; SUPP/1), S498-S504.
- Allen, M.C., Donohue, P.K., & Dusman, A.E. (1993). The limit of viability: neonatal outcome of infants born at 22 to 25 weeks' gestation. *New England Journal of Medicine*, 329, 1597-1601.
- Andersen, L.G., Angquist, L., Gamborg, M., Byberg, L., Bengtsson, C., Canoy, D., . . . Baker, J.L. (2009). Birth weight in relation to leisure time physical activity in adolescence and adulthood: Meta-analysis of results from 13 Nordic cohorts. *Public Library of Science ONE*, 4(12), e8192.



- Andreacci, J. L., Robertson, R. J., Dubé, J. J., Aaron, D. J., Balasekaran, G., & Arslanian, S. A. (2004). Comparison of maximal oxygen consumption between black and white prepubertal and pubertal children. *Pediatric Research*, 56(5), 706-713.
- Astrand, P-O, Rodahl, K, Dahl, HA, & Stromme, SB. (2003). Physical performance: evaluation of physical performance on the basis of tests. In P.-O. Astrand (Ed.), *Textbook of Work Physiology: Physiological Bases of Exercise* (Vol. 4th Edition, pp. 237-299). Stockholm, Sweden: Human Kinetics.
- Beck, Stacy, Wojdyla, Daniel, Say, Lale, Betran, Ana Pilar, Merialdi, Mario, Requejo, Jennifer Harris, . . . Van Look, Paul FA. (2010). The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity. *Bulletin of the World Health Organization*, 88(1), 31-38.
- Biddle, Stuart JH, Gorely, Trish, Marshall, Simon J, Murdey, Ian, & Cameron, Noel. (2004). Physical activity and sedentary behaviours in youth: issues and controversies. *The Journal of the Royal Society for the Promotion of Health*, 124(1), 29-33.
- Blair, S., Goodyear, N.N., Gibbons, L.W., & Cooper, K.H. (1984). Physical fitness and incidence of hypertension in healthy normotensive men and women. *Journal of American Medical Association*, 252(4), 487-490.
- Blair, Steven N, Kohl, Harold W, Barlow, Carolyn E, Paffenbarger, Ralph S, Gibbons, Larry W, & Macera, Caroline A. (1995). Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. *Journal of American Medical Association*, 273(14), 1093-1098.
- Blake, A., Stewart, A., & Turcan, D. (1975). Parents of babies of very low birth weight: long-term follow-up. *CIBA Foundation Symposium Journal*, 33, 271-281.

- Bond, Dale S, Thomas, J Graham, Unick, Jessica L, Raynor, Hollie A, Vithiananthan, Sivamainthan, & Wing, Rena R. (2013). Self-reported and objectively measured sedentary behavior in bariatric surgery candidates. *Surgery for Obesity and Related Diseases*, 9(1), 123-128.
- Bottoms, S.F., Paul, R.H., Iams, J.D., Mercer, B.M., Thom, E.A., Roberts, J.M., . . . McNellis, D. (1997). Obstetric determinants of neonatal survival: Influence of willingness to perform cesarean delivery on survival of extremely low-birth-weight infants. *American Journal of Obstetrics and Gynecology*, 176(5), 960-966. doi: [http://dx.doi.org/10.1016/S0002-9378\(97\)70386-7](http://dx.doi.org/10.1016/S0002-9378(97)70386-7)
- Brown, JR, Cramond, JK, & Wilde, RJ. (1974). Displacement effects of television and the child's functional orientation to media. *The uses of mass communications: Current perspectives on gratifications research*, 93-112.
- Brown, K.J., Kilbride, H.W., Turnbull, W., & Lemanek, K. (2003). Functional outcome at adolescence for infants less than 801 g birth weight: Perceptions of children and parents. *Journal of Perinatology*, 23, 41-47.
- Campbell, Karen J, Crawford, David A, & Ball, Kylie. (2006). Family food environment and dietary behaviors likely to promote fatness in 5–6 year-old children. *International journal of obesity*, 30(8), 1272-1280.
- Castellan, N John Jr. (1988). *Nonparametric statistics for the behavioral sciences*: McGraw-Hill.
- Clemm, Hege, Røksund, Ola, Thorsen, Einar, Eide, Geir Egil, Markestad, Trond, & Halvorsen, Thomas. (2012). Aerobic capacity and exercise performance in young people born extremely preterm. *Pediatrics*, 129(1), e97-e105.

- Cole, Tim J. (2004). Modeling postnatal exposures and their interactions with birth size. *The Journal of nutrition*, 134(1), 201-204.
- Coon, Katharine A, Goldberg, Jeanne, Rogers, Beatrice L, & Tucker, Katherine L. (2001). Relationships between use of television during meals and children's food consumption patterns. *Pediatrics*, 107(1), e7-e7.
- Cooper, DM, Weiler-Ravell, D, Whipp, BJ, & Wasserman, K. (1984). Aerobic parameters of exercise as a function of body size during growth in children. *Journal of Applied Physiology*, 56(3), 628-634.
- Dahan-Oliel, Noémi, Mazer, Barbara, & Majnemer, Annette. (2012). Preterm birth and leisure participation: A synthesis of the literature. *Research in developmental disabilities*, 33(4), 1211-1220.
- Davies, A. A., Smith, G. D., May, M. T., & Ben-Shlomo, Y. (2006). Association between birth weight and blood pressure is robust, amplifies with age, and may be underestimated. *Hypertension*, 48(3), 431-436.
- de Jong, Marjanneke, Verhoeven, Marjolein, & van Baar, Anneloes L. (2012). *School outcome, cognitive functioning, and behaviour problems in moderate and late preterm children and adults: a review*. Paper presented at the Seminars in Fetal and Neonatal Medicine.
- Dong, Ying, & Yu, Jia-Lin. (2011). An overview of morbidity, mortality and long-term outcome of late preterm birth. *World Journal of Pediatrics*, 7(3), 199-204.
- DuRant, Robert H, Baranowski, Tom, Johnson, Maribeth, & Thompson, William O. (1994). The relationship among television watching, physical activity, and body composition of young children. *Pediatrics*, 94(4), 449-455.

- Ericson, A., & Kallen, B. (1998). Very low birthweight boys at the age of 19. *Archives of Disease in Childhood; Fetal and Neonatal Edition*, 78, F171-F174.
- Eriksson, M., Tynelius, P., & Rasmussen, F. (2008). Associations of birthweight and infant growth with body composition at age 15 - the COMPASS study. *Pediatric and Perinatal Epidemiology*, 22, 379-388.
- Fanaroff, A.A, Stoll, B.J, Wright, L.L, Carlo, W.A, Ehrenkranz, R.A, Stark, A.R, . . . Laptook, A.R. (2007). Trends in neonatal morbidity and mortality for very low birthweight infants. *American journal of obstetrics and gynecology*, 196(2), 147. e141-147. e148
- Farooqi, A., Hagglof, B., Sedin, G., Gothefors, L., & Serenius, F. (2007). Mental health and social competencies of 10- to 12-year-old children born at 23 to 25 weeks of gestation in the 1990s: A Swedish national prospective follow-up study. *Pediatrics*, 120(1), 118-133.
- Felsing, NE, Brasel, JA, & Cooper, DM. (1992). Effect of low and high intensity exercise on circulating growth hormone in men. *The Journal of clinical endocrinology and metabolism*, 75(1), 157-162.
- Frontini, M.G., Srinivasan, S.R., Xu, J., & Berenson, G.S. (2004). Low birth weight and longitudinal trends of cardiovascular risk factor variables from childhood to adolescence: the bogalusa heart study. *BioMed Central Pediatrics*, 4.
- Garber, Carol Ewing, Blissmer, Bryan, Deschenes, Michael R, Franklin, Barry A, Lamonte, Michael J, Lee, I-Min, . . . Swain, David P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine & Science in Sports & Exercise*, 43(7), 1334-1359.

- Gardner, F., Johnson, A., Yudkin, P., Bowler, U., Hockley, C., Mutch, L., & Wariyar, U. (2004). Behavioral and emotional adjustment of teenagers in mainstream school who were born before 29 weeks' gestation. *Pediatrics*, 114(3), 676-682.
- Gokce, N., Vita, J.A., Bader, D.S., Sherman, D.L., Hunter, L.M., Holbrook, M., . . . Balady, G.J. (2002). Effect of exercise on upper and lower extremity endothelial function in patients with coronary artery disease. *American Journal of Cardiology*, 90(2), 124-127.
- Goldenberg, R.L., Culhane, J.F., Iams, J.D., & Romero, R. (2008). Epidemiology and causes of preterm birth. *Lancet*, 371(9606), 75-84.
- Goldenberg, R.L., & Rouse, D.J. (1998). Prevention of premature birth. *New England Journal of Medicine*, 339(5), 313-320.
- Goodyer, I. M., Croudace, T., Dunn, V., Herbert, J., & Jones, P. B. (2010). Cohort profile: risk patterns and processes for psychopathology emerging during adolescence: the ROOTS project. *International journal of epidemiology*, 39(2), 361-369.
- Goyen, T.A., Lui, K., & Woods, R. (1998). Visual-motor, visual-perceptual, and fine motor outcomes in very-low-birthweight children at 5 years. *Developmental Medicine and Child Neurology*, 40, 76-81.
- Gray, R., Petrou, S., Hockley, C., & Gardner, F. (2006). Self-reported health status and health-related quality of life of teenagers who were born before 29 weeks' gestational age. *Pediatrics*, 120(1), e86-e93.
- Grunau, R.E., Whitfield, M.F., & Fay, T.B. (2003). Psycho-social and academic characteristics of ELBW (<801g) survivors in late adolescence compared to term-born controls. *Pediatric Research*, 53, 382A.

- Hack, M., Cartar, L., Schluchter, M., Klein, N., & Forrest, C.B. (2007). Self-perceived health, functioning and well-being of very low birth weight infants at age 20 years. *Journal of Pediatrics*, 151(6), 635-641.
- Hack, M., & Fanaroff, A. (1999). Outcomes of children of extremely low birthweight and gestational age in the 1990s. *Early Human Development*, 53, 193-218.
- Hack, M., Forrest, C.B., Schluchter, M., Taylor, H.G., Drotar, D., Holmbeck, G., & Andreias, L. (2011). Health status of extremely low birth weight children at age 8 years: Child and parent perspective. *Archives of Pediatrics and Adolescent Medicine*, 165(10), 922-927.
- Hack, M., Klein, Nancy K., & Taylor, H Gerry. (1995). Long-term developmental outcomes of low birth weight infants. *The future of children*, 176-196.
- Hack, M., Schluchter, M., Cartar, L., Rahman, M., Cuttler, L., Borawski, E., & Klein, N. (2002). Outcomes in young adulthood for very-low-birth-weight infants. *New England Journal of Medicine*, 346, 149-157.
- Hack, M., Taylor, H.G., Klein, N., & Mercuri-Minich, N. (2000). Functional limitations and special health care needs of 10-to 14-year-old children weighing less than 750 grams at birth. *Pediatrics*, 106, 554-560.
- Hallal, P.C., Wells, J.C, Reichert, F.F., Anselmi, L., & Victora, C.G. (2006). Early determinants of physical activity in adolescence: prospective birth cohort study. *British Medical Journal*, 332, 1002-1007.
- Hamilton, B.E., Martin, J.A., & Ventura, S.J. (2013). Births: Preliminary data for 2012. *National Vital Statistics Report*, 62(3), 1-7.

- Hamilton, M.T., Hamilton, D.G., & Zderic, T.W. (2007). The role of low energy expenditure and sitting on obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes*, 56, 2655-2667.
- Hamilton, M.T., Healy, G.N., Dunstan, D.W., Zderic, T.W., & Owen, N. (2008). Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports*, 2, 292-298.
- Hebestreit, Helge, & Bar-Or, Oded. (2001). Exercise and the child born prematurely. *Sports Medicine*, 31(8), 591-599.
- Horbar, Jeffrey D, Carpenter, Joseph H, Badger, Gary J, Kenny, Michael J, Soll, Roger F, Morrow, Kate A, & Buzas, Jeffrey S. (2012). Mortality and neonatal morbidity among infants 501 to 1500 grams from 2000 to 2009. *Pediatrics*, 129(6), 1019-1026.
- Hovi, P., Andersson, S., Eriksson, J.G., Järvenpää, A-L., Strang-Karlsson, S., Mäkitie, O., & Kajantie, E. (2007). Glucose Regulation in Young Adults with Very Low Birth Weight. *New England Journal of Medicine*, 356, 2053-2063.
- Howell, David C. (2014). *Fundamental statistics for the behavioral sciences*: Cengage Learning.
- Johnson, A., Bowler, U., Yudkin, P., Hockley, C., Wariyar, U., Gardner, F., & Mutch, L. (2003). Health and school performance of teenagers born before 29 weeks gestation. *Archives of Disease in Childhood; Fetal and Neonatal Edition*, 88, F190-F198.
- Johnson, Burke, & Christensen, Larry. (2008). *Educational research: Quantitative, qualitative, and mixed approaches*: Sage.

- Johnson, Jeffrey G, Cohen, Patricia, Kasen, Stephanie, & Brook, Judith S. (2007). Extensive television viewing and the development of attention and learning difficulties during adolescence. *Archives of pediatrics & adolescent medicine*, 161(5), 480-486.
- Kajantie, E., Strang-Karlsson, S., Hovi, P., Raikkonen, K., Pesonen, A-K., Heinonen, K., . . . Andersson, S. (2010). Adults born at very low birth weight exercise less than their peers born at term. *Journal of Pediatrics*, 157(4), 610-616.
- Katch, Frank I, & McArdle, William D. (1988). Nutrition, weight control, and exercise.
- Kilbride, H.W., Gelatt, M.C., & Sabath, R.J. (2003). Pulmonary function and exercise capacity for ELBW survivors in preadolescence: Effect of neonatal chronic lung disease. *Journal of Pediatrics*, 143, 488-493.
- Kriska, A. M., Hanley, A. J., Harris, S. B., & Zinman, B. (2001). Physical activity, physical fitness, and insulin and glucose concentrations in an isolated Native Canadian population experiencing rapid lifestyle change. *Diabetes Care*, 24(10), 1787-1792.
- Kriska, Andrea M, Knowler, William C, LaPorte, Ronald E, Drash, Allan L, Wing, Rena R, Blair, Steven N, . . . Kuller, Lewis H. (1990). Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes care*, 13(4), 401-411.
- Kruskal, William H, & Wallis, W Allen. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American statistical Association*, 47(260), 583-621.
- Lefebvre, F., J., Glorieux, & St Laurent-Gagnon, T. (1996). Neonatal survival and disability rate at age 18 months for infants born between 23 and 28 weeks of gestation. *American Journal of Obstetrics and Gynecology*, 174, 833-838.



- Mattocks, C., Deere, K., Leary, S., Ness, A., Tilling, K., Blair, S., & Riddoch, C. (2008). Early life determinants of physical activity in 11 to 12 year olds: cohort study. *British Journal of Sports Medicine*, 42, 721-724.
- McCormick, M.C. (1997). The outcomes of very low birth weight infants: are we asking the right questions? *Pediatrics*, 99, 869-876.
- McCormick, M.C., Workman-Daniels, K., & Brooks-Gunn, J. (1996). The behavioral and emotional well-being of school-age children with different birth weights. *Pediatrics*, 97, 18-25.
- McGowan, Jennifer E, Alderdice, Fiona A, Holmes, Valerie A, & Johnston, Linda. (2011). Early childhood development of late-preterm infants: a systematic review. *Pediatrics*, 127(6), 1111-1124.
- McIntire, Donald D, & Leveno, Kenneth J. (2008). Neonatal mortality and morbidity rates in late preterm births compared with births at term. *Obstetrics & Gynecology*, 111(1), 35-41.
- Melkevik, Ole, Torsheim, Torbjørn, Iannotti, Ronald J, & Wold, Bente. (2010). Research Is spending time in screen-based sedentary behaviors associated with less physical activity: a cross national investigation.
- Miles, M.S., & Holditch-Davis, S. (1997). Parenting the prematurely born child: Pathways of influence. *Seminars in Perinatology*, 21(3), 254-266.
- Mutz, Diana C, Roberts, Donald F, & Van Vuuren, DP. (1993). Reconsidering the Displacement Hypothesis Television's Influence on Children's Time Use. *Communication Research*, 20(1), 51-75.
- Myers, Jonathan, & Bellin, Daniel. (2000). Ramp exercise protocols for clinical and cardiopulmonary exercise testing. *Sports Medicine*, 30(1), 23-29.

- Nelson, Melissa C, Neumark-Stzainer, Dianne, Hannan, Peter J, Sirard, John R, & Story, Mary. (2006). Longitudinal and secular trends in physical activity and sedentary behavior during adolescence. *Pediatrics*, 118(6), e1627-e1634.
- Ng, Carmina, Young, T Kue, & Corey, Paul N. (2010). Associations of television viewing, physical activity and dietary behaviours with obesity in aboriginal and non-aboriginal Canadian youth. *Public health nutrition*, 13(09), 1430-1437.
- Nixon, PA, Orenstein, DM, & Kelsey, SF. (2001). Habitual physical activity in children and adolescents with cystic fibrosis. *Medicine and science in sports and exercise*, 33(1), 30-35.
- Norman, Gregory J, Schmid, Béatrice A, Sallis, James F, Calfas, Karen J, & Patrick, Kevin. (2005). Psychosocial and environmental correlates of adolescent sedentary behaviors. *Pediatrics*, 116(4), 908-916.
- O'Shea, T Michael, Klinepeter, Kurt L, Goldstein, Donald J, Jackson, Barbara W, & Dillard, Robert G. (1997). Survival and developmental disability in infants with birth weights of 501 to 800 grams, born between 1979 and 1994. *Pediatrics*, 100(6), 982-986.
- Oguma, Yuko, & Shinoda-Tagawa, Tomoko. (2004). Physical activity decreases cardiovascular disease risk in women: review and meta-analysis. *American journal of preventive medicine*, 26(5), 407-418.
- Owen, Neville, Leslie, Eva, Salmon, Jo, & Fotheringham, Michael J. (2000). Environmental determinants of physical activity and sedentary behavior. *Exercise and sport sciences reviews*, 28(4), 153-158.

- Page, Angie S, Cooper, Ashley R, Griew, Pippa, & Jago, Russell. (2010). Children's screen viewing is related to psychological difficulties irrespective of physical activity. *Pediatrics*, 126(5), e1011-e1017.
- Paridon, Stephen M, Alpert, Bruce S, Boas, Steven R, Cabrera, Marco E, Caldarera, Laura L, Daniels, Stephen R, . . . Rhodes, Jonathan. (2006). Clinical stress testing in the pediatric age group a statement from the american heart association council on cardiovascular disease in the young, committee on atherosclerosis, hypertension, and obesity in youth. *Circulation*, 113(15), 1905-1920.
- Passmore, R, & Durnin, Jm VGA. (1955). Human energy expenditure. *Physiological reviews*, 35(4), 801-840.
- Pate, Russell R, O'Neill, Jennifer R, & Lobelo, Felipe. (2008). The evolving definition of "sedentary". *Exercise and sport sciences reviews*, 36(4), 173-178.
- Pesonen, A-K., Raikkonen, K., Heinonen, K., Andersson, S., Hovi, P., Jarvenpaa, A.L., . . . Kajantie, E. (2008). Personality of young adults born prematurely: the Helsinki study of very low birth weight adults. *Journal of Child Psychology and Psychiatry*, 49(6), 609-617.
- Phillips, D.I., Barker, D.J., Fall, C.H., Seckl, J.R., Whorwood, C.B., Wood, P.J., & Walker, B.R. (1998). Elevated plasma cortisol concentrations: a link between low birth weight and the insulin resistance syndrome. *Journal of Clinical Endocrinology and Metabolism*, 83, 757-760.
- Powls, A., Botting, N., Cooke, R.W.I., & Marlow, N. (1995). Motor impairment in children 12 to 13 years old with a birth-weight of less-than 1250g. *Archives of Disease in Childhood*, 73, F62-F66.

Pyhala, R., Raikkonen, K., Pesonen, A-K., Heinonen, K., Andersson, S., & Hovi, P. (2009).

*Parental bonding in young adults with very low birth weight.* Paper presented at the Pediatric Academic Societies Meeting, Baltimore, MD.

Rey-López, Juan Pablo, Vicente-Rodríguez, German, Répásy, Judith, Mesana, Maria Isabel,

Ruiz, Jonatan R, Ortega, Francisco B, . . . León, J. (2011). Food and drink intake during television viewing in adolescents: the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Public health nutrition*, 14(09), 1563-1569.

Rideout, Victoria J, Foehr, Ulla G, & Roberts, Donald F. (2010). Generation M [superscript 2]:

Media in the Lives of 8-to 18-Year-Olds. *Henry J. Kaiser Family Foundation*.

Ridgway, C.L., Ong, K.K., Tammelin, T.H., Sharp, S.J., Ekelund, U., & Jarvelin, M-R. (2008).

Birth size, infant weight gain, and motor development influence adult physical performance. *Medicine and Science in Sports and Exercise*, 41(6), 1212-1221.

Robinson, Thomas N. (1999). Reducing children's television viewing to prevent obesity. *JAMA:*

*the journal of the American Medical Association*, 282(16), 1561-1567.

Robinson, Thomas N, & Killen, Joel D. (1995). Ethnic and gender differences in the

relationships between television viewing and obesity, physical activity, and dietary fat intake. *Journal of health education*, 26(sup2), S91-S98.

Robinson, Thomas N, Hammer, Lawrence D, Wilson, Darrell M, Killen, Joel D, Kraemer,

Helena C, Hayward, Chris, & Taylor, C Barr. (1993). Does television viewing increase obesity and reduce physical activity? Cross-sectional and longitudinal analyses among adolescent girls. *Pediatrics*, 91(2), 273-280.

Rogers, M., Fay, T.B., Whitfield, M.F., Tomlinson, J., & Grunau, R.E. (2005). Aerobic capacity,

strength, flexibility, and activity level in unimpaired extremely low birth weight (<800 g)

- survivors at 17 years of age compared with term-born control subjects. *Pediatrics*, 116(1), e58-e65.
- Rowland, Thomas W. (1993). *Pediatric laboratory exercise testing: clinical guidelines*: Human Kinetics Publishers.
- Rowlands, A. V., Eston, R. G., & Ingledew, D. K. (1999). Relationship between activity levels, aerobic fitness, and body fat in 8-to 10-yr-old children. *Journal of Applied Physiology*, 86(4), 1428-1435.
- Sabath, R.J., Teson, K.M., Hulse, J.E., & Gelatt, M.C. (2012). *A new treadmill protocol for the clinical evaluation of children with cardiac disease*. Paper presented at the The XXVIIth International Symposium of the Ueropean Group of Pediatric Work Physiology, Niagara on the Lake, Ontario, Canada.
- Saigal, S., & Doyle, L.W. (2008). An overview of mortality and sequelae of preterm birth from infancy to adulthood. *The Lancet*, 371, 261-269.
- Saigal, S., Lambert, M.I., Russ, C., & Hoult, L. (2002). Self-esteem of adolescents who were born prematurely. *Pediatrics*, 109, 429-433.
- Saigal, S., Pinelli, J., Hoult, L., Kim, M., & Boyle, M. (2003). Psychopathology and social competencies of adolescents who were extremely low birth weight. *Pediatrics*, 111, 969-975.
- Saigal, S., Stoskopf, B.L., Boyle, M., Paneth, N., Pinelli, J., Streiner, D., & Goddeeris, J. (2007). Comparison of current health, functional limitations, and health care use of young adults who were born with extremely low birth weight and normal birth weight. *Pediatrics*, 119(3), e562-e573.

- Saigal, S., Stoskopf, B.L., Streiner, D.L., & Burrows, E. (2001). Physical growth and current health status of infants who were of extremely low birth weight and controls at adolescence. *Pediatrics*, 108(2), 407-415.
- Salt, A., & Redshaw, M. (2006). Neurodevelopmental follow-up after preterm birth: follow up after two years. *Early Human Development*, 82, 185-197.
- Saris, WHM, Elvers, JWH, Van't Hof, MA, & Binkhorst, RA. (1986). Changes in physical activity of children aged 6 to 12 years. *Children and Exercise*, 12, 121-130.
- Schmidt, L.A., Miskovic, V., Boyle, M., & Saigal, S. (2008). Shyness and timidity in young adults who were born at extremely low birth weight. *Pediatrics*, 122, e181-e187.
- Schulz, L. O., Harper, I. T., Smith, C. J., Kriska, A. M., & Ravussin, E. (1994). Energy intake and physical activity in Pima Indians: comparison with energy expenditure measured by doubly-labeled water. *Obesity research*, 2(6), 541-548.
- Stahlman, M.T. (1984). Newborn intensive care: success or failure? *Journal of Pediatrics*, 105, 162-167.
- Stanger, Jeffrey D, & Center, Annenberg Public Policy. (1997). *Television in the home: The 1997 survey of parents and children*: Annenberg Public Policy Center of the University of Pennsylvania.
- Strasburger, Victor C. (2010). Media education. *Pediatrics*, 126(5), 1012-1017.
- Thomasgard, M., Metz, W.P, Edelbrock, C., & Shonkoff, J.P. (1995). Parent-child relationship disorders Part 1. Parental overprotection and the development of the parent protection scale. *Developmental and Behavioral Pediatrics*, 16(4), 244-250.
- Tiukinhoy, S., Beohar, N., & Hsie, M. (2003). Improvement in heart rate recovery after cardiac rehabilitation. *Journal of Cardiopulmonary Rehabilitation*, 23, 84-87.

- Vandewater, Elizabeth A, Shim, Mi-suk, & Caplovitz, Allison G. (2004). Linking obesity and activity level with children's television and video game use. *Journal of adolescence*, 27(1), 71-85.
- Vederhus, Bente J, Markestad, Trond, Eide, Geir E, Graue, Marit, & Halvorsen, Thomas. (2010). Research Health related quality of life after extremely preterm birth: a matched controlled cohort study.
- Vereecken, Carine A, Todd, Joanna, Roberts, Chris, Mulvihill, Caroline, & Maes, Lea. (2006). Television viewing behaviour and associations with food habits in different countries. *Public health nutrition*, 9(02), 244-250.
- Verschuur, R, & Kemper, HCG. (1985). Habitual physical activity. *Med Sport Sci*, 20, 56-65.
- Vrijlandt, Elianne JLE, Gerritsen, Jorrit, Boezen, H Marike, Grevink, René G, & Duiverman, Eric J. (2006). Lung function and exercise capacity in young adults born prematurely. *American journal of respiratory and critical care medicine*, 173(8), 890-896.
- Wang, ML, Dorer, DJ, Fleming, MP, & Catlin, EA. (2004). Clinical outcomes of near-term infants. *Pediatrics*, 114(2), 372-376.
- Warburton, D., Gledhill, N., & Quinney, A. (2001). Musculoskeletal fitness and health. *Canadian Journal of Applied Physiology*, 26, 217-237.
- Warburton, D., Nicol, C.W., & Bredin, S. (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*, 174(6), 801-809.
- Wightman, A., Schluchter, M., Drotar, D., Andreias, L., Taylor, H.G., Klein, N., . . . Hack, M. (2007). Parental protection of extremely low birth weight children at age 8 years. *Journal of Developmental and Behavioral Pediatrics*, 28, 317-326.

- Williams, Tannis MacBeth. (1986). *The impact of television: A natural experiment in three communities*: Academic Press.
- Wilson, Peter WF, Paffenbarger Jr, Ralph S, Morris, Jeremy N, & Havlik, Richard J. (1986). Assessment methods for physical activity and physical fitness in population studies: report of a NHLBI workshop. *American heart journal*, 111(6), 1177-1192.
- Wood, N.S., Marlow, N., Costeloe, K., Gibson, A.T., & Wilkinson, A.R. (2000). Neurologic and developmental disability after extremely preterm birth. *New England Journal of Medicine*, 343(6), 378-384.
- Yliharsila, H., E., Kajantie, Osmond, C., Forsen, T., Barker, D.J., & Eriksson, J.G. (2007). Birth size, adult body composition and muscle strength in later life. *International Journal of Obesity*, 31, 1392-1399.



## Appendix A

ID# \_\_\_\_\_

### PAST YEAR LEISURE-TIME PHYSICAL ACTIVITY

I am going to read you a list of activities kids your age might do. Please let me know any that you have done at least 5 or more times in the past year (from mon to mon). Do not include activities that you did in school phys ed or gym class.

Aerobics  
Band/Drill Team  
Baseball  
Basketball  
Bicycling  
Bowling  
Cheerleading  
Dance Class  
Football  
Garden/yard work  
Gymnastics  
Hiking

Ice Skating  
Roller Skating/Blading  
Running for Exercises  
Skateboarding  
Snow skiing  
Snow boarding  
Soccer  
Softball  
Street Hockey  
Swimming (Laps)  
Swimming (Play)

Tennis  
Trampoline Jumping  
Volleyball  
Walking  
Water Skiing  
Weight Training  
Wrestling  
Others:  
\_\_\_\_\_  
\_\_\_\_\_

Activity	J a n	F e b	M a r	A p r	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c	Months per Year	Days per Wk or mon	Minutes per Day

## Appendix B

### WAKE FOREST UNIVERSITY SEDENTARY BEHAVIOR QUESTIONNAIRE (WFU SBQ)

“The next questions I am going to ask you are about sedentary activities, like watching TV. I am going to ask you to tell me how much time you spend doing these activities during a typical school week. I am going to ask you separately for schooldays (mon-fri), and then for weekend days (sat and Sunday). I am interested in the time you spend doing these activities outside of school, i.e. before or after school. ”

**For first activity ask, “How much time do you spend during a typical school week on schooldays [activity]:**

Record number of minutes per day X number of days, or total for weekdays (and weekend days).

Ask same for weekend.

Repeat for each activity.

Activity	Weekday Minutes	Weekend Minutes
Watching television or movies		
Using the computer (playing video games, surfing the internet, etc.)		
Reading (aside from homework)		
Sitting while Listening to music (not doing any other mentioned already)		
Sitting while Talking on the telephone		
Sitting while Hanging out with friends (not doing any other activity listed)		
Texting on the telephone		

## Appendix C



### APPROVAL OF PROTOCOL

February 11, 2014

Kelli Dudley  
kedudley@ku.edu

Dear Kelli Dudley:

On 2/11/2014, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Physical activity levels and sedentary behaviors for extremely low-birth-weight survivors in later childhood
Investigator:	Kelli Dudley
IRB ID:	STUDY00000740

The IRB approved the study on 2/11/2014.

1. Any significant change to the protocol requires a modification approval prior to altering the project.
2. Notify HSCL about any new investigators not named in original application. Note that new investigators must take the online tutorial at [https://rgs.drupal.ku.edu/human\\_subjects\\_compliance\\_training](https://rgs.drupal.ku.edu/human_subjects_compliance_training).
3. Any injury to a subject because of the research procedure must be reported immediately.
4. When signed consent documents are required, the primary investigator must retain the signed consent documents for at least three years past completion of the research activity.

Please note university data security and handling requirements for your project:  
<https://documents.ku.edu/policies/IT/DataClassificationandHandlingProceduresGuide.htm>

Sincerely,

Stephanie Dyson Elms, MPA  
IRB Administrator, KU Lawrence Campus

### Appendix D

	Original ELBW Cohort (n=41)	ELBW sample (n=17)	p value	Original Late Preterm Cohort (n=42)	Late Preterm sample (n=21)	p value	Original Full-Term Cohort (n=26)	Full-Term sample (n=23)	p value
Birth Weight-grams Mean $\pm$ SD	671.24 $\pm$ 85.96	691.06 $\pm$ 67.36	p=0.401	2011.45 $\pm$ 261.45	1953.24 $\pm$ 281.37	p=0.420	3446.62 $\pm$ 573.35	3615.33 $\pm$ 621.29	p=0.385
Gestational Age-weeks Mean $\pm$ SD	25 $\pm$ 1.40	24.76 $\pm$ 1.25	p=0.550	33.38 $\pm$ 1.67	33.1 $\pm$ 1.67	p=0.524	39.54 $\pm$ 0.95	39.4 $\pm$ 0.91	p=0.650
Race (%)									
Caucasian	30 (73.2%)	12 (70.6%)	p=0.837	32 (76.2%)	17 (81.0%)	p=0.749	22 (84.6%)	12 (52.2%)	p=0.015*
Black	9 (22.0%)	4 (23.5%)		9 (21.4%)	4 (19.0%)		3 (11.5%)	11 (47.8%)	
Asian	0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Hispanic	1 (2.4%)	1 (5.9%)		0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Biracial	0 (0.0%)	0 (0.0%)		1 (2.4%)	0 (0.0%)		1 (3.8%)	0 (0.0%)	
Other	1 (2.4%)	0 (0.0%)		0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Supplemental oxygen at 36 weeks									
Yes	19 (47.5%)	6 (35.3%)	p=0.396	0 (0.0%)	0 (0.0%)	p=n/a	0 (0.0%)	0 (0.0%)	p=n/a
No	21 (52.5%)	11 (64.7%)		42 (100%)	21 (100%)		26 (100%)	15 (65.2%)	
Discharged with supplemental oxygen									
Yes	13 (32.5%)	6 (35.3%)	p=0.838	0 (0.0%)	0 (0.0%)	p=n/a	0 (0.0%)	0 (0.0%)	p=n/a
No	27 (67.5%)	11 (64.7%)		42 (100%)	21 (100%)		26 (100%)	15 (65.2%)	

\*p&lt;0.05